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MORTALITY AND ACCIDENTS FROM LIGHTNING.

By W. Marriott, *Secretary of the Royal Meteorological Society.*

THERE seems to be an undue dread of the danger of lightning. Many people are during a thunderstorm seized with a sense of terror which upsets their nervous system, and brings on headache and other physical ills that are usually referred to the electrical condition of the atmosphere, instead of to their own mental condition. When we come, however, carefully to inquire into the number of deaths caused by lightning, it is a matter of surprise and comfort that the mortality is so small.

In a paper recently communicated to the Royal Meteorological Society by Inspector-General Lawson, it was shown that the total number of deaths caused by lightning in England and Wales during the twenty-nine years—1852 to 1880—as recorded in the returns of the Registrar-General, was 546, the yearly average being 19. The average annual rate in a million persons is 0·879. Thunderstorms are more frequent and violent in some years than in others, and consequently the numbers of deaths by lightning fluctuate considerably. For instance, there were only 3 deaths in 1863, and 6 in 1864, while there were 45 in 1852 and 46 in 1872.

In other countries the number of persons killed by lightning is much greater than in England. Colonel Parnell, in his book, "The Action of Lightning," gives accounts of accidents in various parts of the world, from which we may form an approximate idea of the relative proportion of deaths in some of the European countries. Thus, in Russia (not including Poland and Finland) there were 2,270 persons killed by lightning in the five years, 1870–74, the yearly average being 454, or 5·22 per million; in Prussia there were 1,004 persons killed in the nine years 1869–77, the yearly average being 112, or 4·15 per million; in France there were 1,308 persons killed in the eighteen years, 1835–52, the yearly average being 73, or 1·93 per million; in Switzerland there were 33 persons killed in the two years, 1876–77, the yearly average being 17, or 5·92 per million; and in Sweden there were 664 persons killed during the sixty-two years, 1816–77, the yearly average being 11, or 2·37 per million.

The mortality from lightning is much greater among the inhabitants of rural districts than those of towns. There can be no doubt that the lightning conductors attached to churches, &c., as well as the various large buildings, serve to silently diffuse the electricity, and so deaths from lightning strokes are rarer in towns than in the open country. The recently-erected Eiffel Tower is reported to have a very modifying effect on a thunderstorm, as it forms a perfect lightning conductor. On one occasion, when a very black thundercloud, from which lightning was being emitted, passed over Paris, the lightning ceased as soon as it came within the influence of the Tower, whilst it appeared again when the cloud passed onwards.

The returns of the Registrar-General show that the mortality from lightning is greater amongst men than amongst women, the deaths of males being 81 per cent. and of females only 19 per cent. This great excess of deaths of males is no doubt due to the fact that men are more engaged in field labour and outdoor occupations, and are consequently more exposed to the dangers of thunderstorms than women. The greatest number of deaths among males occurs between the ages of 15 and 25.

The effect of lightning is not always the same; some persons are killed instantaneously and their bodies marked in a curious manner, others are rendered unconscious, and perhaps lose the use of their limbs or faculties for a time or permanently. Frequently when persons are struck their clothes are completely stripped off their bodies and hurled a considerable distance away. At the Royal Meteorological Society's Exhibition in March 1888 the clothes of a man who had been struck by lightning were exhibited; these had been blown off his body, and were almost in ribbons. His boots were burst out, and his watch partly fused. The man was not killed, but recovered after being in the hospital for some weeks.

On June 14, 1888, a slight thunderstorm passed over the north of London, when two men were struck by lightning at the Spaniard's Farm, Hampstead Heath. They were eating their dinner under a tree when the occurrence took place. One of them was rendered quite senseless, and appeared as though he were dead. The other heard a tremendous thunderclap, and was quite stunned for some minutes, but felt no pain. He then found that his trousers were smouldering, that his knife had been knocked out of his hand, and that his steel buckles had been torn off his legs. He succeeded in quenching the fire in his trousers, and managed to crawl to the road, shouting for assistance. After a time they were both conveyed to the infirmary. Their features were ghastly blue, with a dull yellowish white showing through the leaden colour. The elder one was almost pulseless, but after a time became slightly conscious. He had burns on his right side from the shoulder to the feet. Photograph 1 shows the appearance of the scars and markings on his arms and back a month after the accident. I had an opportunity of examining and photographing the clothes worn by these men. These are shown in Photograph 2.

An interesting case of the disruptive force of lightning is exhibited in Photograph 6, which is a reproduction of a photo-

Hants, on 20th May, 1887.

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graph of the boots worn by some children who were struck by lightning in Atcham Church, near Shrewsbury, in July, 1879. Sometimes the body of a person struck by lightning has markings on it of an arborescent or tree-like character. A very interesting photograph of such markings on the arm of a boy who was struck by lightning at Duns, Berwickshire, was obtained in June 1883. The boy, who was thirteen years of age, had sought shelter with three other boys in a stable when the occurrence took place; he was thrown to the ground and hurt about the face and forehead by the fall. His father, who is a chemist, writes:—

"The motion of the arms was for some while completely paralysed, inasmuch as he was unable until some considerable time after regaining consciousness to remove his hands from his pockets, where he had placed them before the accident. There was also in the arms a sensation of numbness and cold, and he fancied that they had been broken at the elbows. Other voluntary movements were at first inaccurate and unsteady. Later, upon his complaining of a burning heat in the arms his coat was removed, and markings of an arborescent character were discovered stretching from below the left elbow to the shoulder, and throwing branches of a less complicated character across the left chest. The marks were of a ramified, tree-like form, and seemed to radiate from two centres, as if the lightning had first struck the arm in two places, and had thence broken over the surrounding skin. Shortly after the accident the boy walked home without assistance, and on his arrival the marks were subjected to a closer inspection. They proved of a red colour, somewhat similar in shade to that of the spots of measles or scarlet fever. The surface of the skin was slightly raised over them, and the superficial heat of the injured arm was greater than that of the rest of the body. For two hours after the stroke they retained their original appearance, remaining to the naked eye at least perfectly unaltered. By 7.30 P.M., eight and a half hours after the accident, they were hardly visible, and at ten o'clock next morning had entirely disappeared."

Animals are much more frequently struck by lightning than human beings, probably from being more exposed to the storm, and also from taking shelter under trees, which are sometimes struck. Animals are, no doubt, quite as much terrified, if not more so, than human beings during a thunderstorm, and consequently huddle together. The heated moist air rising from their bodies forms a ready path for the lightning discharge, and consequently we frequently hear of two or more animals being killed by the same flash.

The vagaries of lightning are very strange. Sometimes one sheep only in a flock is killed, the others being untouched, or two horses may be standing side by side, when one is struck and the other uninjured. Colonel Parnell quotes a case in which sixteen natives and five oxen were killed at one discharge on the high road in Natal in 1878. A diver under water in Cole Harbour, Halifax, N.S., was rendered insensible, the air-pump having been struck by lightning. Coal mines are not apparently exempt from lightning discharges, as there is evidence to show that on July 12, 1880, lightning actually entered the workings of the Tanfield Moor Colliery.

When the lightning strikes sand it sometimes fuses it and forms what is called a "fulgurite," which is a kind of vitrified hollow tube. Some of these tubes have been found 30 or 40 feet long. Two interesting specimens of fulgurites are to be seen in the British Museum.

Trees are perhaps the objects most frequently struck by lightning. In some instances the bark only is torn off, while in others a large limb or the trunk of the tree itself is completely shattered. The shivering of the trees into small splinters is probably due to the sudden heating of the sap, which is driven into steam; the wood is consequently blown to pieces. Photographs 4 and 5 are reproductions of photographs of some trees which have been struck by lightning.

ON THE DISRUPTIVE EFFECTS OF LIGHTNING, AND ON DARK FLASHES.

BY A. C. RANYARD.

WE are indebted to the kindness of Mr. G. J. Symons for the loan of the two photographs of lightning-struck trees and of the burst boots worn by children in Atcham Church when it was struck by lightning ten years ago. Mr. Symons has during the last twenty years made a large collection of photographs of objects shattered and torn by lightning, and we hope that we shall at some future time be permitted to draw still further on his interesting store for the benefit of the readers of KNOWLEDGE.

Frequently only a narrow strip of bark is blown from the side of a lightning-blasted tree. The strip of bark often remains attached by its upper end, like the great splinter in our picture of the poplar in Regent's Park. It must not be assumed too readily from such an appearance that the explosion took place at an appreciably earlier instant at the lower part of the tree than in the part above, indicating, as has often been assumed, that the flash was an upward one. It is possible that the direction of the splinters only indicates that the explosive forces acted with greater energy below than above. When we consider the velocity of the current as compared with the time which would be occupied in tearing elastic splinters of wood, this seems to be the more probable explanation.

When the bark is only blown away, the shining surface of the *cambium* layer or outer ring of growing cells just below the bark is left exposed; this is the region where there is most sap, and it is generally assumed that the explosion is caused by the moisture of the growing cells being suddenly converted into steam. But the cells of the cambium layer do not generally appear to be charred, or as if they had been exposed to such heat as would instantaneously drive fluids into vapour. The explosive force also acts occasionally evidently with great energy in the central parts of the trunk where there are no growing cells. The great oak at East Tisted, shown in the lower picture, is an excellent example of this. The clergyman standing beneath it is the Rev. Wm. Howlett, known to readers of KNOWLEDGE by his admirable drawings of sun-spots. He serves us here as a standard of comparison by which the size of the great oak may be more readily realised.

The vapour-explosion theory will evidently not account for all the disruption which takes place along the line of discharge; frequently lightning shatters stone and sometimes glass, within which there can be no moisture to explode. We know that a sudden local change of temperature will shatter stones sometimes with great violence, producing noises which in the case of meteorites are probably heard over greater areas than any of the artificial explosions produced by modern artillery; but mere expansion due to the sudden development of heat will not account for the shreds into which the clothes of the lightning-struck sawyer referred to by Mr. Marriott have been torn. The clothes are not charred or singed, except in places, although the bodies of the unfortunate men were badly scorched. In the *British Medical Journal* for August 4, 1888, one of these sawyers is described as having "burns on the right side from his shoulder to his feet, bearing the appearance of

abrasions. The whole of this side (presumably the side on which he was leaning against the tree) had exactly the appearance of an exaggerated example of *post-mortem* staining; the other sawyer had his legs burnt in places from the point where he had been resting his knife downwards. The legs were cut probably by the steel buckles he had worn. . . . Both men were so scorched that no lines were visible to indicate the course taken by the electric current, although these subsequently came out as shown in the illustration."

It is evident from this description that the skin of the men must have been subjected to great heat as well as to pressure, which caused the abrasions and the bruising. The fact that the injury done was chiefly to the skin and surface tissues shows that the seat of the explosion was on the surface of the body. The current seems to have travelled along the damp surface of the skin and to have driven the moisture into vapour, which blew the clothes outward in rags without singeing them.

It is a curious fact that the boots of lightning-struck persons are nearly always burst open. The sawyers' boots, with torn "uppers," may be seen on the top of the small barrel in Mr. Marriott's photograph, and the children's boots show evidence of a disruptive force upwards, not in the direct line of discharge to or from the earth and the child. This is what might be expected on the theory that the explosion is due to moisture on the skin, which is driven into vapour. The leather of the boot would confine the perspiration, and the weakest part of the boot would go. We shall probably learn more as to the action of the electric current in producing death when the American electric methods of execution have been in use for some little time. From the facts before us at present it would seem as if a dry-skinned criminal would suffer differently from one who had struggled on his way to the scaffold and was perspiring freely.

The very interesting photograph of lightning in the lower left-hand corner of the plate was taken by the Rev. A. Rose, at Emmanuel College, Cambridge, on the evening of June 6 last. It shows the main flash bright, with dark branches spreading away from it on either side. In all other photographs of branching flashes the main flash has been brighter than the branches; we may, therefore, probably assume that in this instance the main flash was the brightest, and that the fainter flashes are reversed, while the brighter flash is not reversed. On looking more closely into the photograph, one sees that the main flash is bordered along its edges by a dark fringe corresponding to the hazy edge of the image of a bright object, described in the last number of KNOWLEDGE as due to the optical imperfections of the instrument with which the photograph was taken. This dark border to the main flash can just be seen on the photographic copy published with this. It will also be noticed that the brighter parts of some of the branches, notably the middle one on the left-hand side, are only partly reversed. In the glass transparency which I have before me, one can see that a narrow line of light runs down the central part of the branch near to where it joins the main flash. Evidently the brighter parts of the flash have given rise to bright images, and the less bright parts have reversed the photographic action produced by the background of sky, and have given rise to an area on the photographic plate which is darker than the surrounding area of sky. Taken in conjunction with the experiments described by Mr. Clayden in his letters, and with the older experiments on the reversing action of the less refrangible rays, referred to in the letter of Sir G. G. Stokes, we seem to have material here for a very interesting research. The background of sky was lit up by summer twilight rich in long wave-lengths, the blue end of the spectrum having been sieved out by the long passage of the solar light through the lower air. The light of the lightning, richer in short wave-lengths, seems to have first bleached or reversed the photographic action of the reddish light of the sky, and then to have produced its own positive effect. If this theory is correct, how is it that this particular photograph of a branching flash is the only one which shows the branches and fainter parts of the flash reversed? Possibly this photograph was taken on a background of clear sky, while other flashes have been photographed on a background of cloud. We need further observations. In experimenting, one is generally on the verge of discovery when one comes to something one does not understand. Here there is a great deal which needs explanation. If the reversing effect of one region of the spectrum with respect to another is proved, more rapid photographic action may possibly be obtained by eliminating the reversing wave-lengths by passing the light which is to form the image to be photographed through a coloured medium, which will sieve out the reversing rays.

THE COMMON COCKROACH.—I.

By E. A. Butler.

UNDER this name some may perhaps hardly recognise the insect so well known as a kitchen nuisance, and popularly called a "black beetle." A more inappropriate name than black beetle could hardly be conceived: the epithet "black" is apparently applied in a loose sort of way to indicate merely a dark colour, for, when closely examined, the creature is seen to be really reddish brown of a deeper or brighter tinge according to age and sex, only approaching black in the older females, and then merely on the back. Again, in many important structural characteristics as well as in the nature of the changes it undergoes in the course of its life, it is widely removed from the true beetles. Not but that there *are* black beetles (*Blaps*, &c.) rightly named, that domicile themselves with man, lurking in cellars and outhouses; but these are totally different insects from *Periplaneta orientalis* (fig. 1), the common cockroach, with which we are now concerned, and they never appear in enormous swarms in our kitchens as the cockroach frequently does.

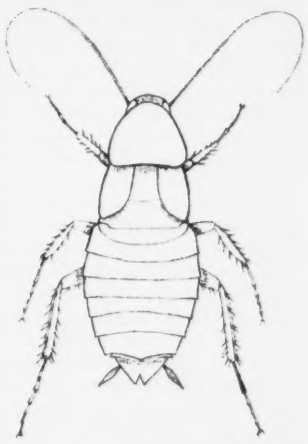

Fig. 1.—The Common Cockroach (*Periplaneta orientalis*) Female.

English soil did not produce this much-maligned insect; it is an immigrant from foreign parts. It is, in fact, not an inhabitant of temperate climates at all, but came originally from the tropical parts of Asia. While importing cargoes of the productions of other countries, we often unwittingly and unintentionally add considerably to our own insular fauna. Probably no shipload of animal or vegetable produce from distant lands starts for our ports without the accompaniment of an assemblage of living creatures, chiefly insects, from the

same parts of the globe. Such of these as survive the voyage stand a chance, after unshipment, of becoming naturalised, if only they can speedily find suitable food and a locality which yields a congenial temperature. Amongst such established importations, of which we may now count some dozens of examples, the common cockroach stands pre-eminent as regards both size and numbers, and is probably as cordially hated as any of them except the bed-bug. When the first Asiatic cockroach set foot in Britain, it is impossible to say with certainty, but it was probably not more than about four centuries ago. By the end of the sixteenth century, they had been introduced into the two chief maritime countries of Europe—England and Holland; but we do not get any specific notice of them in zoological literature till near the middle of the seventeenth century, when we read of them as found in flour mills, wine cellars, &c., in England. At this early date, it was, of course, only the seaport towns, and principally London, that were frequented by the insect, and it took a long time to spread to inland and country districts—indeed, in all probability, the conquest of England by the cockroach is hardly yet complete. Gilbert White, writing towards the close of the last century, speaks of the cockroach as an unusual insect in the village of Selborne, saying that he had never seen it in his house before, and no doubt there are even now remote country places whither it it has not yet penetrated.

Cockroaches are strictly nocturnal in habits, seeking in the daytime the utmost concealment. Hence it happens that they often exist in our houses in multitudes that are perfectly unsuspected until one surprises them in their midnight revels. You visit the kitchen after the lights are out; and as you approach a faint rustling, like the rattling of distant rain, or the pattering of tiny feet, catches your ear. You throw a light on the scene, and on the floor stands revealed a sort of Pandemonium, crowded with dark forms hurrying hither and thither, hastening to get into obscure corners away from the glare of the hateful and unexpected light. But when you go in again by daylight they have all disappeared, and no trace of them can be seen. They have packed and squeezed themselves away into niches, cracks, and crevices, under sacks or matting, behind jars or pans, or even under boards, bricks, or stones—anywhere to be out of the light. The flatness of their bodies gives them unusual facilities for thus bestowing themselves.

They have a double reason for frequenting the kitchen premises. First, a tolerably high temperature is essential to their well-being, as might be expected of importations from the tropics; they cannot stand cold, and much less than the frosts and snows of winter is sufficient to kill them. Therefore they have the good sense to take up their quarters in that part of the house where artificial warmth is most constantly kept up. Then, again, the kitchen regions are the land of plenty, and contain things edible to a greater extent than the rest of the house. Not that they are at all fastidious as regards diet; the most unpromising materials yield them sustenance, and they will absolutely thrive on what might have been supposed to be totally innutritious. They are truly omnivorous; articles of human food, both animal and vegetable, are much to their taste, but they do not stop at these; woollen clothes, newspapers, blacking, ink, leather, and even emery paper will do equally well, and they will even devour their own cast skins, and enjoy a cannibal feast on the corpses of their relations. Professor Moseley records how, during the circumnavigating voyage of H.M.S. *Challenger*, a number of cockroaches, stowaways on the voyage, established themselves in his cabin, and devoured parts of his boots, "nibbling off all the margins of leather projecting beyond the seams on the upper leathers."

The same naturalist gives an amusing account of the attempts he made to rid himself of one particularly unpleasant visitor (apparently a different species from *P. orientalis*, though of similar habits), which seems to have manifested a considerable degree of intelligence. He says: "One huge winged cockroach baffled me in my attempts to get rid of him for a long time. I could not discover his retreat. At night he came out and rested on my book-shelf at the foot of my bed, swaying his antennæ to and fro and watching me closely. If I reached out my hand from bed to get a stick, or raised my book to throw it at him, he dropped at once on the deck, and was forthwith out of harm's way. He bothered me much, because when my light was out, he had a familiar habit of coming to sip the moisture from my face and lips which was decidedly unpleasant, and awoke me often from a doze. I believe it was with this object that he watched me before I went to sleep. I often had a shot at him with a book or other missile as he sat on the book-shelf, but he always dodged and escaped. His quickness and agility astonished me. At last I triumphed by adopting the advice of Captain Maclear, and, shooting him with a pellet of paper from my air-gun, a mode of attack for which he was evidently unprepared."

On board ship cockroaches, of one kind or other, often do much damage. Mr. R. H. Lewis speaks of two kinds of them attacking a cargo of 300 cases of cheeses. Holes had been left in the packages to prevent the cheeses from "sweating," and the cockroaches thus found entrance and damaged them considerably, devouring a great quantity and befouling all. Their disgusting odour, arising from a fœtid fluid poured out from the mouth, renders them far more obnoxious than they would otherwise be, and often causes food to be spoiled by their proximity.

In the perfect condition the male and female cockroaches differ considerably. The males are smaller and less robust than the females; they stand higher on their legs, *i.e.*, do not allow their abdomens to trail along the ground as their partners do, and are furnished with two pairs of wings, the females being apterous, or nearly so. The upper pair of wings, called *elytra* or *tegmina* (fig. 2, A) are rather stiff and horny, and being dark coloured, do not easily show the very peculiar course of the so-called nervures; but the under pair, called specifically *wings* (fig. 2, B) are membranous and transparent, and the nervures can be easily seen. In repose the wings are folded in half lengthwise, the inner half being bent under the outer, and then itself folded like a fan, and they are then covered by the elytra much as in a beetle, though in that case the folding would be transverse instead of longitudinal, and the elytra would not, as they do here, overlap. When closed the elytra cover the greater part of the back. The females simply have a rudimentary pair of elytra (see fig. 1) and no wings at all, and flight is impossible to them.

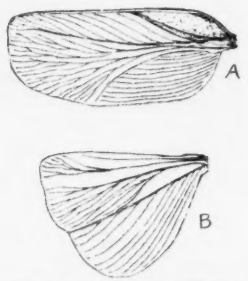

Fig. 2.—A, Elytron; B, Wing, of Male Cockroach.

A cockroach issues from the egg, not, like many insects, with a form totally unlike that of its parents, but shaped very similarly to the adult, and differing from that chiefly in its minute size, its pale colour, and the absence of wings. These young cockroaches may often be seen in kitchen hearths in great numbers—little pale whitey-brown creatures, running about with extreme agility, and moving their legs so quickly that they seem to skim along or glide over the ground. As they grow, like other insects they cast their

skins periodically, after each moult becoming larger and darker. During the first year of its life the young cockroach changes its skin three times; the first immediately after hatching, the second a month later, and the third not till the end of the year. There would appear to be seven moults in all before the fully developed form is attained, but after the first three these are made only annually. This, at least, is the conclusion arrived at by Cornelius from observations made on captive cockroaches; but it may be open to question whether the course would have been precisely the same under more natural conditions, and, unfortunately, no other observations have been recorded on this particular species. If, however, the above results represent the usual state of things, cockroaches are certainly gifted with extraordinary longevity, for their life evidently extends over a period of at least five years. One is accustomed to think of insects as truly ephemeral creatures, and it is probable that the majority of them do not require more than a single twelvemonth to complete their cycle of existence; where the preliminary stages occupy a longer time than this, the species chiefly feed in concealment—as buried in the ground, like the grubs of the cockchafer, or in solid wood, like those of the stag-beetle. The experience of Sir John Lubbock with his ants has, it is true, demonstrated that the life of insects may, under favourable conditions, last much longer than we should have expected. Some of his ants lived with him upwards of eight years; but these were in their perfect condition all that time, and their early life and periods of transformation and growth had been, as usual, rapidly accomplished. Cockroaches, on the other hand, if the above results are to be accepted, take a long time to pass through their introductory stages, but we have no evidence at all as to how long they live after becoming full-grown. To so active an insect the dangers and possible mischances of a long larval life would necessarily be very numerous, and it is highly probable that great numbers of them would never reach maturity at all. Be that as it may, their swarms are still quite large enough for human comfort. Further observations on their life history, however, are much to be desired, though no doubt difficult to carry out. A closely allied species, *Blatta germanica*, was studied by Hummel with a very different result, the generations being found to succeed one another with much greater rapidity, and analogy suggests that *P. orientalis*, which is similarly an active surface-living insect, should run a similar course, and should, at any rate, complete its cycle of changes more rapidly than sluggish grubs which live in solitariness and concealment.

(*To be continued.*)

THE PRODUCTION OF SUGAR.

By Ward Coldridge, B.A. Cantab.

YESTERDAY the formation of sugar by plants was one of the mysteries of nature. Chemists and botanists, whilst they knew that ordinary chemical attractions must be the cause, were yet completely in the dark as to how these forces worked. They realised that plants started with carbonic acid and water, and from these waste products of animal existence built up in some unknown way the complex compound, sugar. From the deadly choke-damp to the luxury sugar was a great transformation. The plants could thus build; but men of science could not comprehend the process.

To-day, as the result of some brilliant researches, the explanation has been found. A simple compound, the formation of which by the plant can be readily accounted for, has been transformed into a sugar. To understand the process, it must be realised that abundant evidence proves that plants promote processes which are the opposites of combustion or oxidation. Plants liberate oxygen from its compounds, and absorb that with which it was previously combined. They can liberate oxygen from so stable a compound as carbonic acid, and in water find a source for the hydrogen which is essential to their development. The products which could thus be formed are, respectively, from carbonic acid, the lower oxide of carbon and oxygen, from water, the gases hydrogen and oxygen. Experiments have shown that under the influence of the silent electric discharge, and even without it, carbon monoxide and hydrogen combine to form a simple compound, formic aldehyde, which is immediately connected with the formic acid of the ant and of the stinging-nettle. So the changes which occur in the plant under the combined influence of sunlight and chlorophyl may be represented in symbols as follows:—

$$\underset{\text{Carbonic acid.}}{CO_2} = \underset{\text{Carbonic oxide.}}{CO} + \underset{\text{Oxygen}}{O} \quad ; \quad \underset{\text{Water}}{H_2O} = \underset{\text{Hydrogen}}{H_2} + \underset{\text{Oxygen.}}{O}$$

$$CO + H_2 = \underset{\text{Formic aldehyde.}}{CH_2O}$$

This formic aldehyde was the substance experimented on. When it was suitably treated in the presence of the hydrate of lime ($Ca(HO)_2$), it was induced to combine with itself and to form another compound. The latter is composed of the same ultimate indivisible particles (atoms) and in the same proportions; but they are now differently arranged side by side, and with a larger number in the unit aggregation which chemists call molecules. This compound has now been finally proved to contain not one, but at least two or three members of the family of substances, carbohydrates, to which sugar belongs. Thus in our laboratories can now be imitated the process of which plants previously held the secret.

Whilst, however, the fact is marvellous that a sugar has been obtained artificially, it must be remembered that the process is absolutely uneconomical, for the yield is very small. This remark too applies to another process of artificial production. The sweet viscid liquid, glycerin, and its stinking, irritating offspring, acrolein, which gives the nasty smell of burning fat, have both been transformed into sugar; but the quantity obtained is very small in proportion to the glycerin or acrolein used. The importance of these researches lies in the fact that they show how the chemical changes which characterise the vital action of the plant can be imitated with dead matter, and that further they shed a bright gleam of light on the hitherto obscure question of the arrangement of the indivisible particles, atoms, within the compound particles, the molecules of these substances.

Our supply of sugar will always be drawn from the vegetable kingdom, the synthetic laboratory of nature. Many plants work hard and economically at the production of sugar, and form it in quantity. It occurs in all parts of plants—root, stem, leaves, flower, fruit, and seed. In some grasses it is very abundant, in the sugar-cane, in the Sorgho grass, and in the young shoots of the maize. In the common carrot and parsnip, and especially in the fleshy beet, large quantities are contained. But for its commercial extraction two sources are chiefly used—the sugar-cane and the beetroot, and a third is of growing importance, the Sorgho grass.

The sugar-cane has far greater natural advantages than the beetroot. At one time the former held the field without a rival. But during the Napoleonic wars, France was deprived of her supply of sugar, and she was driven to

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produce her sugar at home. This resulted in the commencement of the beet-sugar industry, and thus amongst the secondary results of war must be reckoned bounty-fed sugar. To judge of the economic aspects of the two industries, many factors have to be taken into account. When that has been done, this balance will be found distinctly in favour of the cane. Sugar-canes contain sufficient sugar to yield 70 to 80 per cent. of their weight of juice, in which there is some 20 per cent. of sugar. Beet-roots, as an extended series of investigations have shown, possess a percentage of sugar varying from 7 to a maximum of under 14, and on the average about 11. Now an acre of land which can be used for beet-growing will be rented for, say, 4*l.* per annum, whilst in the colonies an equal area of cane-producing land will be rented for about one-tenth of that amount. Further, a great divergence is found in the quantity of beet and cane which two equal areas can grow. For instance, in the environs of Magdeburg, an acre will yield about 10 cwt. of sugar; whereas, in the home of the sugar-cane, some 40–50 cwt. can be obtained. Then other items in the cost of production have to be considered; the difference in wages in the two regions, the difference in the cost of fuel—in Europe where coal is necessary, in the colonies where the waste matter of the cane supplies the whole, or nearly the whole, of the fuel required. One can thus realise the grounds on which the Brazilian Commission on the sugar industry reported, that, in their opinion, "the cost of production may be reduced in Brazil to such a degree as to defy competition, and the struggle between cane and beetroot must become ominous to the latter, which thrives only by the artificial advantages which European countries have devised."

Hitherto the artificial advantages have been on the side of the European countries; but now the greatly improved means of transit, and the diffusion of knowledge, are raising the colonists to a position nearer equality in these respects, of course excluding bounties. And by this time the colonial sugar planter has learnt a severe lesson. He understands that, whilst nature has showered her gifts on him with a lavish hand, she mercilessly punishes him for carelessness and lack of promptitude. For if he cuts his canes, they must within a few hours be crushed and extracted; if he is negligent, and leaves them for only two days, fermentation rapidly ensues under the conditions of tropical temperature, and the canes turn sour and must be thrown aside for fuel. In this way nature has fined men whole fortunes. Great fortunes have been made in the manufacture of sugar; but of these processes, with their special points of interest, an account must be reserved.

EARTH-WORMS—II.

BY E. MANSEL SYMPSON, M.A., M.B. Cantab.

LET us look for a minute at the diagram, which represents a section of the earth-worm's body cut clean through the middle, as it will give a clear idea of the relation of parts inside the worm. On the outside, all round, you see there is the skin (*α* in the diagram) pierced in four places by pairs of hairs (*δ*) which have special muscles at their inner ends to make them stand on end, as indeed our own hairs have, but they are little used by us save when we see a ghost, or think we do. Beneath the skin come the circular bands of muscular fibre; within those again are four bands of longitudinal muscle, cut across. Then we come to a space—the body cavity, which you remember was formed by the hollowing-out of those masses of mesoblast. This communicates with the outside world in each segment by a couple of coiled and curved tubes, opening at one end into the cavity of one

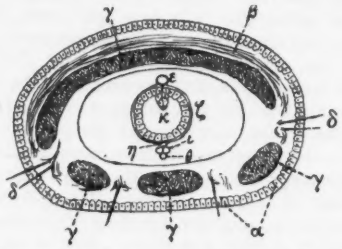

FIG. 4.—TRANSVERSE SECTION OF MATURE EARTH-WORM.
α, epidermis; *β*, circular muscles; *γ*, longitudinal muscles; *δ*, hairs; *ε*, dorsal blood-vessel; *ζ*, "heart;" *η*, sub-intestinal blood-vessel; *θ*, sub-neural blood-vessel; *ι*, double nerve-cord; *κ*, intestine, with dip (Typhlosole) from upper surface.

segment, running through the partition-wall, and out through the body-wall of the next segment. They are plentifully supplied with blood, and serve as kidneys for the animal. On the upper surface of the intestine you see the dorsal blood-vessel, with the so-called heart leading down to join the sub-intestinal vessel; below the latter is the double nerve-cord, and below that the sub-neural blood-vessel. Then in the middle is the intestine cut across, with its muscular coat and special lining membrane and that curious dip from its upper surface. No special breathing-apparatus is found, as worms breathe by their skin. The two sexes are united in the same individual, but two individuals pair together. As for senses, the earth-worms are rather badly off. They have no eyes, and have been thought quite insensible to light. But Mr. Darwin found that when the light was concentrated and long-enduring they certainly showed some perception of it. This, however, only occurred when the light was allowed to fall especially on the anterior end of the body; consequently it probably affected the ganglia above the pharynx by passing through the skin. In the rest of the body you will remember the nerve-cord and ganglia lie directly under the intestinal canal, and so are more shielded from the action of light. Probably this perception of light is quite enough—poor as it may seem—to enable them to distinguish between day and night. Somewhat in the same way as we go to sleep at night twenty-four hours after twenty-four hours, so do the earth-worms disappear into their burrows at the dawn to re-appear with the darkness of night. It seems to have become an habitual action with them, incapable of being changed with changed conditions, for a number of worms kept by Mr. Darwin in pots covered by glass plates with black paper spread carefully over, and placed before a north-east window, behaved exactly as worms generally do—they came out at night and remained in their burrows during the day. Earth-worms also are quite deficient in the sense of hearing; they will take no more notice of the shrill, ear-piercing note of a penny whistle than of the deepest and loudest tones of a bassoon. But worms are wonderfully sensitive to vibrations in solid matter; when placed in pots on a piano which was being played, one gentle note was quite enough to send them back into their burrows, like a rabbit to his hole. And a common way of catching worms is to beat the ground with a spade, whereupon they come out in numbers. All over its body is the worm sensitive to contact. A slight puff of air will cause an instant retreat; but the most highly developed part in this respect is the oral end, by moving which about it gains a general im-

pression of the size and shape of surrounding objects. Their sense of smell is shown in the choice and selection of different kinds of food. Cabbage-leaves and bits of onion, buried beneath a ¼-inch of earth, were almost greedily run after; the worms in well nigh every instance discovered them, and dragged them out. As you might fairly expect in an animal so comparatively omnivorous as the earthworm, he possesses a very decided sense of taste. Onions, cabbage, the common or garden green cabbage especially, are liked by them. Celery they devour seemingly with a relish. They also manage to swallow an enormous quantity of earth. They don't object to liquorice. They don't mind whether their meat is cooked or raw; but, above all else in the meat line, a bit of raw fat seems to titillate their palate most. Cannibals are they, for they will gnaw away unconcernedly at the half of a dead brother's body; but you cannot expect much sentiment in an animal with only two cerebral ganglia to represent its brain, and six pulsating arteries for a heart. Their digestive fluid differs in no respect from that of higher animals: it acts on fat, on the fibrin of meat, on starch, and on the cell-walls of leaves and other parts of plants, a very useful thing, you can imagine, for an animal which lives chiefly on half-decayed leaves, whereof the cell-walls are almost three-fourths of the nutriment, for of course the meat diet is not obtained save by one in a thousand, who happens to fall in with a kindly collector. Earthworms take kindly to milk, in which it would be a good thing if more of mankind imitated them. Also it is interesting to note that the secretion wherewith worms moisten the leaves they drag into their burrows partially digests them, which may remind us of the digestion of flies, &c., on the leaves of the sundew.

The distribution of earth-worms is wide, almost universal. In England they inhabit the commons and chalk-downs as well as the London parks, with their different qualities of soil. In the grassy paths across moors they abound, and in paved courtyards you may often come across evidence of their presence. Their castings have been found at various heights from 1,500 to 4,000 feet above the sea, on Schiehallion in Scotland, on some hills near Turin, and on the Himalayas. You count them terrestrial animals, that is, animals which inhabit the earth, though they have been kept alive for nearly four months completely submerged in water. Also they want a damp air to live in, as was proved by exposing some to the dry air of a room for a single night: in the morning they were all dead. A few remarks here on their relations and the class to which they belong seem to fall in naturally. One, almost the nearest, of their relations is the leech—everyone knows the medicinal one, if they do not know the common horse-leech of ponds. Then there are fresh- and salt-water worms. When you examine the latter, which generally secrete a tube wherein they dwell, such as the beautiful *Serpula*, with its crown of tiny ostrich feathers, you find they have a special apparatus — the gills — whereby they breathe. Most people must have seen the coils of sand which are so frequent between high and low water-mark on the shore, and to explain whose construction saintly or demoniacal aid has been invoked. These are the casts of the lug-worm, greatly in demand for bait. Then the free-swimming *Nereids*, as they are prettily called, are worms of wonderfully exquisite colour, changing with each movement of the animal. The sea-mouse, *Aphrodite*, too, comes near to these, with its hairy coat sparkling in the sun with every imaginable play of colours. It is also notable as having gills of rather curious construction on its back, acting somewhat like the respirators wherewith people try to mitigate the piercing chill of a "wild north-easter."

Most families, if not all, have, they say, some poor relations, or, if not exactly poor, so disreputable that they never mention them. The earthworms are no exception to this rule. Their parasitic relatives must not be mentioned to ears polite. That word parasitic recalls something about the leech. You may count it as a parasite, since it lives on the blood of other animals, and as such obeys the same laws as other parasites. In common conversation, when we call a man a parasite, we mean to imply that he is a degraded being: it is much the same among animals. You will almost universally find that a parasitic animal has become degraded from what is believed to be his original position in his class. Somewhat in the same way as an endowment or an assured position has been the ruin of many a man who might have turned out a fine specimen of humanity if he had had his own way to make in the world; so, when your animal gets a great deal of the work of procuring and preparing food done for him, he gets lazy and sinks lower in the scale of animal life. The neighbouring classes to the earth-worms are lowest of all the Protozoa, already mentioned, containing the *Amœba*, *Ophrydium*, and the like. Then the Cœlenterata, with *Hydra*, the sea-anemones, and the jelly-fishes. Next we get to the Echinoderms, some of which are known much better by their commoner name of star-fishes. Our earthworms and their relations form the class above; while just above them, in turn, come the Arthropods, including lobsters, centipedes, spiders, and insects. Above them, again, are the mollusks, the fresh-water mussel, the oyster, and the common snail.

Now to turn to a more interesting part of my subject—the habits of earth-worms. I mentioned that their upper lip was useful for seizing articles of food; they take hold of the edge of a leaf, for example, between the upper and lower lips, with a very firm grasp. But when they have to deal with broad flat objects, they act in a totally different way. The anterior end of the body is withdrawn a little within the first three or four segments, so as to form a flat end to the body; this flat end, something like the end of a pencil-case, is then applied to the cabbage-leaf or a slice of onion, and a vacuum is produced whereby the worm gets a tight hold of it. Worms are fond of leaves, not only as food, but also to use for plugging up the mouths of their burrows, and for lining their walls, probably so as to protect their bodies from the cold earth around. They also protect the mouths of their burrows with little heaps of stones, which they drag from some distance—by suction as well. Mr. Darwin thought these plugs were apparently to keep out the cold air, and to keep the air already within thoroughly damp, which, as we have seen, is essential to a worm's happiness, and even to his existence. Now the manner in which these leaves were dragged into the burrows is interesting. As the tip of a leaf is generally the smallest and narrowest part of it, probably if you or I had to use these leaves for wall-papers in our "diggings," we should drag them in by the tip. Mr. Darwin examined over two hundred leaves of different kinds which had been in the earthworms' burrows, and nearly eighty out of each hundred had been dragged in by the tips. A good number of these were leaves of the lime, which are very pointed at the top, and gradually swell out to a broad base with a well-developed foot-stalk. The rest of these leaves were drawn in partly by their base, partly by their middle,—probably the stiffness of the leaves had a great deal to do with this latter portion. Then Mr. Darwin tried the leaves of laburnum, which are quite as pointed at the base as at the tip; and the worms dragged a good many more of these in by the base, nearly thirty out of a hundred. But still, the larger part by far were dragged in by their tips, showing that worms have probably acquired

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the habit of avoiding the footstalk, unless the leaf, by narrowing down to it, makes things more even. Also pine leaves, consisting of two needle-like blades, joined to a common base, were almost invariably drawn in by that base. Mr. Darwin observed many worms by a dim light actually dragging these and other leaves into their burrows, and he remarks, "It appeared to my son and myself as if the worms instantly perceived as soon as they had seized a leaf in the proper manner." And I have examined a good many split seed capsules of the laburnum, which the worms seem very fond of; and they were almost always drawn in by the tip and not by the base. Now, as worms are not guided by special instincts in each case, though possessing a general instinct to plug up their burrows, and as chance is excluded, the most probable conclusion is that they try a variety of ways of drawing an object into their burrows, and at length succeed in some one way to which they stick. But it is rather putting the cart before the horse to tell you of the lining of the burrows, when I have said hardly a word about the mode of making these burrows. This is done in two ways, partly by the anterior end of the worm acting as a wedge, and so pushing the earth away on all sides, and partly by the worm actually swallowing the earth. The two modes of action seem to be chosen with regard to the character of the earth in which the worm is burrowing. For instance, in loose garden soil, they were observed many times in the act of making their burrows; but they appeared to swallow little if any of the soil. Again, in fine sand which had been pressed down and well watered, they swallowed a large quantity. Earth-worms undoubtedly do swallow a good deal of earth—especially the dark vegetable mould—for food, and it is only on this plea that we can explain the multitudes of castings you can see each morning, which are quite inexplicable if we suppose these are only thrown up like piles of bricks and mortar, when the inhabitant is enlarging his house or building a new one. As a rule the burrows are not deep, but in cold weather, as well as in cold countries such as Scotland and Scandinavia, they have been noticed to run down for 7 or 8 feet, and Mr. Darwin says that in England he has frequently known them extending downwards for 3 or 4 feet. They are generally lined by a layer of dark and fine earth which has passed through the worm's body, they generally run straight down, and are rarely branched. When you look at an earth-worm's burrow, you would think it certainly never could turn round inside. But it must do so, for the excretion of the earth or casting is done with its tail first on one side and then on the other, and the tail is used almost like a trowel, while the mouth catches hold of leaves. These castings vary greatly in size: some of the largest ever measured were 6 inches high and $1\frac{1}{2}$ inches thick. There are two methods of estimating the quantity of earth brought to the surface in any given time: one by the rate at which objects left on the surface are buried; another, a still more accurate way, by weighing the quantity brought up within a given period. Let us take an example. Mr. Darwin in his book on earth-worms (from which a good deal of the information in this paper has been gathered) states that a piece of waste swampy land near to his house was enclosed, drained, ploughed, harrowed, and thickly covered with burnt marl and cinders in the year 1822. It was sown with grass-seed, and now supports a fair but coarse pasture. Fifteen years after, i.e. in 1837, holes were dug in this land. It was found that the turf was $\frac{1}{2}$ inch thick, beneath which was a layer of vegetable mould $2\frac{1}{2}$ inches in thickness. It was quite free from any fragments of any kind, but beneath it again was a layer of mould $1\frac{1}{2}$ inches thick, full of bits of burnt marl, conspicuous from their red colour, and coal cinders. Below this layer, and at a depth of $4\frac{1}{2}$ inches from the surface, was the original black peaty soil with some quartz pebbles in it. Thus in only fifteen years a layer of fine vegetable mould $2\frac{1}{2}$ inches thick had covered the land. Now as to the weight of the castings. When kept in confinement, it has been found that they only gave out eight grains daily. But when you weigh separate castings obtained out of doors, some actually weigh over an ounce each. Off a small piece of turf about 22 feet square, I have collected at one sweep nearly two pounds of castings. In England the largest castings are found in the poorest land, as though the worms had to swallow more earth to get the same amount of nourishment from it.

OUR MICROSCOPIC FOES.

OUR DEFENCES.

By A. Winkelried Williams.

In guarding ourselves against an enemy we should always keep three things in mind: how to act on the defensive against attacks by the foe; how to act on the offensive, and destroy or disable the foe; and how, should defeat be overshadowing us, to take advantage of the better part of valour, and run away. So in the Bacterio-Human war must we be ready with an effective combination of the above three actions in order that the victory may be ours. When all the forces of our bodies are acting in unity—that is to say, when we are in our natural condition of perfect health—we are practically invulnerable against the foes' attack, unless it be made by an abnormally great multitude. We are naturally encased in a suit of armour wondrously and perfectly made. A layer, or series of layers, of epithelial cells covers every surface of the body; these cells are carefully cemented together by a small amount of interstitial matter. The armour varies in structure according to the requirements of the different surfaces which it covers and the functions these surfaces perform. The beautiful manner in which the structure is adapted to the function is well seen by examining the epithelium covering the skin and the respiratory surfaces.

The function of the skin epithelium, exposed as it is to great friction and to bacteria innumerable, is mainly protective. It consists of many layers. The cells in the lower of these layers are formed of soft protoplasm, and are continually multiplying. As they grow older they become flattened and horny, until on the surface we find scales of horny keratin; these are continually being rubbed off. The skin, however, has also another function, *i.e.*, the secretion of sweat. Accordingly we find the epithelium altered in places so as to form sweat glands; these consist of tubes of a delicate epithelium. This delicate epithelium is protected by a very fine and comparatively long and tortuous duct leading to the surface.

In the respiratory passages we find other forms of epithelium. In the pharynx and larynx we have a stratified squamous epithelium resembling the skin surface; below this we have a far more delicate and beautiful arrangement. The windpipe divides into the two main bronchial tubes; these subdivide over and over again and finally end in narrow passages, around which are clustered a number of minute vesicles just visible to the naked eye. These passages, excepting the terminal ones, are lined by a stratified ciliated epithelium, which is modified here and there into mucous glands and mucous cells. The surface cells are the largest, and are provided with many minute cilia. These cilia are continually moving in such a manner

as to allow the mucus secreted by the glands to be gradually moved upwards. When bacteria and other particles are inhaled they are drawn down into the larger bronchi by the inspiratory effort, and come in contact with the lining epithelium with its covering of sticky mucus; to this they adhere and are lashed up by the cilia to be expectorated. The terminal air vesicles and passages, where the exchange of gases between the blood and the atmosphere chiefly takes place, have a lining of only a single layer of flattened cells. Two circumstances protect these: firstly, in ordinary respiration the air is not drawn down to these cells with any force, it merely diffuses into them, and the bacteria probably would have been caught by the mucus above; secondly, the nervous mechanism here is readily stimulated by an irritating particle such as a tubercle bacillus, and the result is a forced emptying of the passage by a cough, which drives upwards the irritant. When by any chance the healthy continuity of the epithelium is broken and the entrance of bacteria allowed, there is still a battle to be fought. If the injury has not seriously lowered the vitality of the tissues, most bacteria will have but a poor chance of life. There are the scavengers already referred to; normally their vitality exceeds that of the bacteria they devour. The chemical processes occurring everywhere in our bodies also do much to destroy bacteria. Possibly also the rapidity of the blood-stream may have something to do with their destruction; we know that active motion is antagonistic to their life outside the body, and therefore the same influence may act within.

It is of course possible for an army, if sufficiently numerous, to overcome defences, however complete they may be. The admirable natural defences of the healthy living body can be thus broken down by abnormally great numbers of bacteria. In Koch's experiments on the tubercle bacillus, he showed that the inhalation of them in great numbers by healthy guinea pigs readily caused tuberculosis; the injection of them into the blood produced the same result. Another striking example is the case of the micrococci of suppuration; if we apply a poultice of these to the human skin a boil results. In nature, however, we are practically never exposed to such extreme conditions. There are also certain bacteria whose virulence is so great, that probably but few of us could resist them when once introduced into the system. Such is the case with the bacillus that causes that fatal disease of cattle called anthrax, and which often causes a similar disease in men, especially among farriers and wool sorters.

We now come to the consideration of the second method of defence, viz., how to destroy and disable the foe. An important way of getting rid of our bacterial foes is to cut off their supplies, destroy their habitations and means of locomotion. In towns the proper attention to sanitary arrangements, the proper disposal of the drainage, the efficiency of the water supply, the cleanliness of the streets, houses, and people are some of the principal modes in which this part of the warfare can be carried on. The avoidance of dust is also important. It has already been stated that the bacteria in the air are principally carried by particles of dust; but another reason is that the continual inhalation of many particles of dust by itself causes irritation to the lungs, and is apt to produce chronic inflammatory mischief, the results of which give opportunities for the entrance of bacteria. Thus in many trades, such as needle-grinding and stone-cutting, the proportion of deaths from consumption is terribly great.

The direct destruction of bacteria by implements of war is also demanded. The principal implements we use are poisons and heat. These we term disinfectants and antiseptics. The disinfectants are those which directly kill the organisms and their spores, the antiseptics those that hinder their development and stop their spore formation. Important poisons are corrosive sublimate, carbolic acid, arsenic, chlorine, and many others. Their relative value cannot be discussed here; in fact, it is a subject much disputed. By these agents we can destroy the bacteria where they are known to exist to a dangerous degree, such as in fever chambers, mortuaries, drains, &c. Their use in epidemics is evident.

Heat is a disinfectant, and, moreover, it is one of the most important we have. Dry heat is less powerful than moist heat: in using it the temperature of over 284° Fahr. must be prolonged for some time to make sure of killing both the organisms and their spores, while steam at 212° rapidly kills all bacteria. Heat is greatly used to disinfect clothing, &c., and the heat used in cookery is an important agent in times of epidemic, especially of diseases affecting the alimentary tract, such as typhoid and cholera. In these cases the boiling of water and of milk is very important. In reference to tuberculosis, the boiling of milk is a matter of very serious importance, especially in towns where cows are kept in stables for dairy purposes. Cows under such unnatural conditions are very apt to become tubercular, and unfortunately when affected they may show but little or no external evidence of the disease. The milk of tubercular cows very frequently contains a great abundance of tubercle bacilli; hence the danger. Epidemics of scarlet fever have also been traced to the use of unboiled milk.

It is a common practice in warfare to make our enemies destroy each other. We can sometimes do this with the foe under consideration. Some bacteria thrive on certain soils much better than others; these will outgrow and starve out the less favoured. In some cases such antagonistic actions can take place in the body. For example, there is an antagonistic action between the anthrax bacillus and erysipelas micrococcus. If we take two animals susceptible to anthrax disease, and inoculate them both with the bacillus, then a short time afterwards inoculate one of them with erysipelas virus, the result is that the one which has simply had the anthrax inoculated dies, the other lives. It is one of the great aims of modern medical investigations to try and cure grave diseases by giving the patient another of a comparatively trivial and curable character. In connection with this we recognise the friendly actions of some bacteria, which, although unpleasantly stimulating our olfactory apparatus by their volatile secretions, do us great service in choking out others that might be a source of serious danger.

There are many bacterial diseases of which one attack, even though of the most trivial character, protects the patient from a future attack. The reason of this is at present a mystery. From this it is evident that, if we can disable the power of bacteria, so that a slight attack may be given, a great advantage is obtained. This has been done in several ways—by giving the disease to a different animal, and collecting the virus from it; by cultivating the organisms in some non-living medium for many generations, or by cultivating them under some peculiar conditions, such as excessive heat. The earliest and by far the greatest good done for mankind in this way was through the researches and brilliant discovery of vaccination by Edward Jenner many years before such things as bacteria were even heard of. He discovered that smallpox, after having passed through the cow, was converted into a disease so simple as to cause only the trivial results of proper vaccination. Vaccination does not give complete immunity from smallpox, but mitigates its character; by it one of the most horrible of diseases, malignant smallpox, has practically ceased to exist, and in its place we find a comparatively trivial disease, *i.e.* the smallpox of the present day.

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In late years mitigation of the virus of other diseases has been accomplished by repeated cultivations. Anthrax was firstly so mitigated by Professor W. S. Greenfield. M. Pasteur afterwards made similar investigations on anthrax. While Professor Greenfield was mitigating the anthrax bacillus, M. Pasteur was doing the same with fowl cholera, and published his results at about the same time. The bacteria of acute pneumonia also have their virus rapidly weakened by successive cultivations. Later still are the results of Pasteur in mitigating the virus of hydrophobia.

We now come to the consideration of the last part of our defences, *i.e.*, the ways of safe retreat. The first great thing is to get fresh air. The proper ventilation of our houses is now well known to be an absolute necessity for the maintenance of health, and it is a subject directly connected with the bacterial question. For when we ventilate our houses we not only get a fresh supply of oxygen and get rid of carbonic acid gas, but we at the same time get rid of the dusty and bacteria-laden air that is found in crowded localities. But even the best arrangement of ventilation is not sufficient in crowded workshops; this, however, can be remedied by those who live in such places taking a few hours of vigorous outdoor exercise daily. The exercise should be vigorous, so that the stagnant air in the lungs may be got rid of, and that the lungs may be well dilated with fresh air. The necessity for this is greater in men with big chests. The lungs of such men when they do not have proper exercise are not fully dilated, and are apt to become contracted and unhealthy at the apices, thus leaving a convenient place for the insidious attacks of the tubercle bacillus. The truth of the above statement is painfully exemplified in the case of shopmen who are confined in shops, often ill-ventilated, and who have no proper time for daily exercise excepting Sundays, when they are often too tired to take advantage of a day with few outdoor attractions. It is here that we very frequently find victims of consumption. It is also an important matter that we should be able to occasionally leave the town for a week or two in order that we may recruit our strength and repair any point in our defences that may be weakened by the foe's attack, and of course this can be done more thoroughly when as few of the enemy are about as possible.

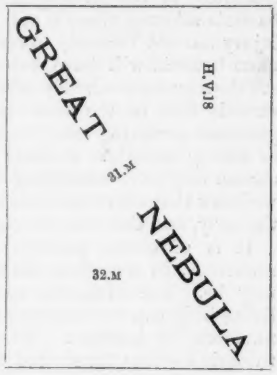
There are some people who should never live in crowded towns. I refer to those belonging to consumptive families. We have all heard of hereditary consumption; it is, however, extremely doubtful whether a child is ever born consumptive; the evidence goes to show that children are born with a tendency to tuberculosis, not with the disease actually existent. Such people should live in a mild climate, a climate as nearly uniform as possible and in country places, better by the sea. By this and by living regular lives, the chances of the disease may be decreased. Of course there are immense difficulties in finding the above ways of retreat. How can the majority of mankind get away for holidays in the country? How can they get regular exercise in fresh air? The sooner the above problem can be solved the better for the health, the happiness, and for the morality of the race. For when our bodies are diseased, the cells of our brains cannot act properly, and the strength of our minds depends upon the vigorous action of the little cells of which the active parts of our brains are composed.

MISS C. W. BRUCE, of New York, has presented fifty thousand dollars to Harvard College Observatory, which the director, Professor E. C. Pickering, proposes to spend in the purchase and endowment of a photographic telescope of 24 inches aperture. The object glass will be a compound lens of the form used by photographers, and known as a portrait lens. This form of lens permits of a short focus, and gives a large field with good definition.

THE GREAT NEBULA IN ANDROMEDA, 31 MESSIER.

ON the opposite page is a photographic reproduction, enlarged about three diameters, from the best negative which Mr. Isaac Roberts has taken of the Andromeda Nebula. It shows a good deal more detail in the outer parts of the nebula than can be traced on the enlargement published with the March number of KNOWLEDGE, which is on a smaller scale.

In the picture which we now offer to our readers the nebulous masses breaking up into clusters of nebulous points or small stars which lie along the outer whorl of the great nebula are well shown, and the stellar centre of the small elliptic nebula H.V. 18 is just traceable. All three nebulæ (31 Messier, 32 Messier, and H.V. 18) have stellar centres, but the central parts of the great nebula are entirely lost in the enlargements. On the original negative there are some curious dark patches and branching channels in the neighbourhood of the inner dark spiral and on the more central parts of the nebula. Some similar dark patches or markings can be seen in the enlargement to the north of the small nebula 32 Messier, and at the north following end of the inner great channel, some of the more marked of these dark patches appear to be associated with stars to which they are adjacent. The nebula lies in the neighbourhood of the Milky Way, and we should expect to find as many stars projected upon it, or seen through it, as are to be found in an adjacent area of equal extent, but, making allowance for such stars unconnected with the nebula, there seem to be stream-lines of stars which fall in with the general alignement of the dark channels and the great streams of nebulous matter, as well as evident groups of small stars or nebulous points forming knots of nebulous matter in the outer whorl of the nebula. These are better seen in the original negative than on the enlargement, but some of the knots of nebulous haze on the outer whorl are distinctly shown on the enlargement broken up into nebulous points.



On the original negative no trace of spiral structure can be seen in either of the two small nebulæ, H.V. 18 or 32 Messier. The nuclei of all three nebulæ appear to the naked eye like stars; but when the negative is examined with a microscope, they are seen to differ in character from the other star discs on the plate. They are quite black, but have less definite edges than star discs of equal magnitude. The appearance shown would seem to indicate that there is a rapid condensation in brightness towards the centre, but that there is no stellar nucleus.

It should be mentioned that in order to facilitate comparisons with other drawings, the North point has been placed uppermost upon the page. A similar remark applies to the picture of the Pleiades Nebula given in the February number, while telescopic views with the south point uppermost have been given of the other nebulæ figured in recent numbers of KNOWLEDGE.

A. C. R.

THE GREAT NEBULA IN ANDROMEDA.

31 Messier, enlarged about three diameters from the original negative taken by Mr. Isaac Roberts, on Dec. 29th, 1888.

CUNNINGHAM & LAWRENCE COLLEGE HILL, E.C.

XUM

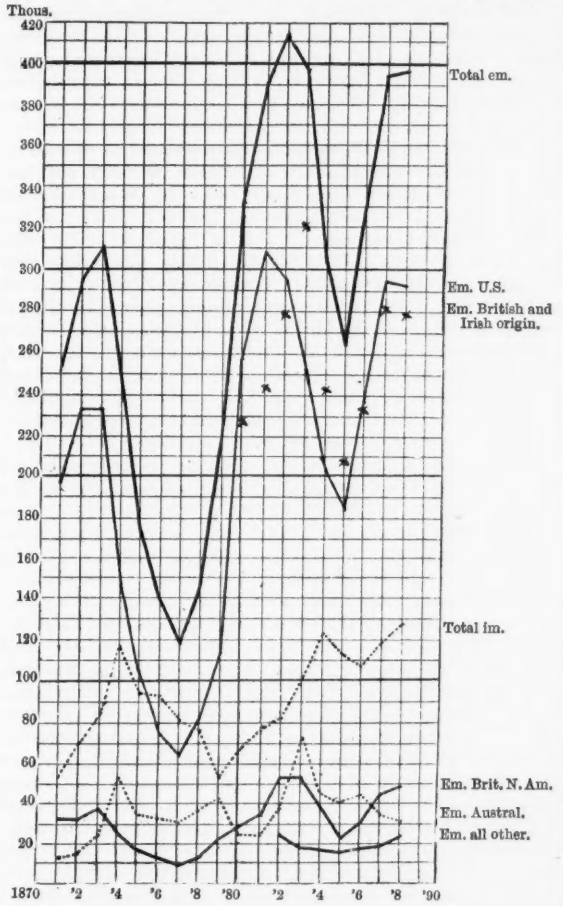
XUM

EMIGRATION.

By ALEX. B. MACDOWALL, M.A.

PASSING through the variations due to births, deaths, emigration, and immigration, the population of the United Kingdom is supposed to grow at the rate of something like a thousand a day. What do we know, in the statistical way, about those who leave our shores for foreign countries? The annual Government returns of emigration relate to only a portion of this class—passengers, viz., to places outside of Europe (and of non-European ports of the Mediterranean). On the other hand, many of those included in the figures are not true "emigrants," meaning to settle abroad, but of the travelling or tourist class. This is especially true of cabin passengers; who have been rapidly growing in numbers (from 40,000 ten years ago, to 65,000 last year, which is about a sixth of the total of so-called emigrants).

We have, then, to consider the numbers of those who leave our shores for the United States, British North America, Australasia, and other (non-European) countries. The uppermost curve in the first diagram, drawn from figures since 1871, shows that this stream varies greatly in

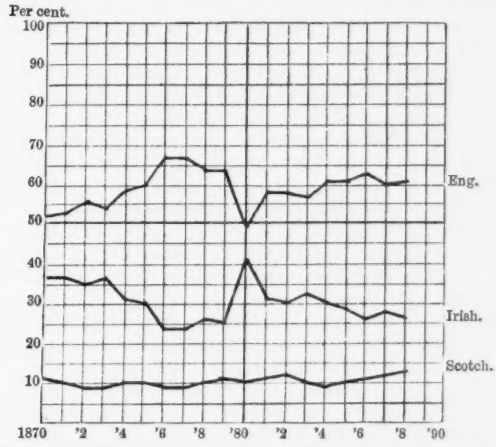


1. EMIGRATION AND IMMIGRATION (U.K.)

volume. Thus, from 119,000 in 1877, it grew to 413,000 in 1882, *i.e.* nearly fourfold in five years. These were the lowest and the highest figures in this period. A less maximum was reached in 1873 (310,000), and a less minimum in 1885 (264,000). We seem to be now at another turn of the curve from a high point (not so high as in 1882). Last year's figures (398,000) were but slightly higher than those of the year before, and this year's returns to the end of May show a distinct falling off from the same period last year (155,000 against 186,000). The majority of those "emigrants" are of British or Irish origin. But a large proportion are foreigners, who use the route *viâ* the United Kingdom to foreign parts. The crosses in our diagram indicate the numbers of our own people for a few years. Last year there were 279,000 out of 398,000, the rest being foreigners.

How is the stream of emigration distributed? Most goes to the United States, of course; they had about 70 per cent. last year (the number being 293,000, which is slightly less than the year before). The curves for British North America and Australasia cross and recross, now the one country, now the other, gaining a preponderance. At present British North America is in the ascendant, and its curve is tending upwards, while that of Australasia is tending downwards. Last year the former had about 13 per cent. of the emigrants, the latter about 11. The recent rise in the curve of all other places (given in part only) is probably connected, in part, with the gold discoveries in the Transvaal. Emigration to Central and South America is also increasing. The total number of immigrants from those same countries last year was about 128,000. Note how the curve of immigrants (the upper dotted one) somewhat corresponds with, but lags in its phases behind, the emigrants' curve.

In our second diagram we show how the English, Irish, and Scotch elements have varied in proportion of the totals



2. PERCENTAGES OF ENGLISH, SCOTCH, AND IRISH EMIGRANTS.

of our people emigrating. The English last year were 61 per cent. of the whole, the Irish 26 (as against 37 at the outset), and the Scotch 13. There was a large increase of Irish emigration in 1880, the percentage reaching 41 (1879 was a memorably bad year in Ireland); but since then, it will be seen, the proportion has been going down. The Scotch, on the other hand, have been growing in proportion since 1884.

It is a curious fact that while the English and Scotch adult male emigrants are very much in excess of the females, sometimes nearly twice as many, and the foreign (adult males) more than twice as many, the Irish males and females are nearly equal in number; in some recent years there has even been a small excess of females. The Scotch

emigrants include the highest proportion of children (22 per cent. last year), the Irish the least (10·8 per cent.). The great bulk of the English emigration is from Liverpool, that of the Scotch from Glasgow and Greenock, that of the Irish from Queenstown. Of the adults emigrating last year, some 80,000 are described as "general labourers," 29,000 (female) "domestic and farm servants, nurses, &c.," 24,000 "agricultural labourers, gardeners, carters, &c.," 20,000 "mechanics," 14,000 "gentlemen, professional men, merchants, &c.," 11,000 "farmers and graziers," 5,000 "miners and quarrymen," 3,000 "clerks and agents," 3,000 "shopkeepers," and so on.

GROWTH AND DECAY OF MIND.

By the late R. A. Proctor.

> And so from hour to hour we ripe and ripe,
> And then from hour to hour we rot and rot,
> And thereby hangs a tale.—*As You Like It.*

EW subjects of scientific investigation are more interesting than the inquiry into the various circumstances on which mental power depends. By mental power I do not mean simply mental capacity, or the potential quality of the mind, but the actual power which is the resultant, so to speak, of mental capacity and mental training. The growth and development of mental power in the individual, and the process by which, after attaining a maximum of power, the mind gradually becomes less active, until in the course of time it undergoes at least a partial decay, form the special subjects of which I propose now to treat; but in order to form clear ideas on these subjects it will be necessary to consider several associated matters. In particular, it will be desirable to trace the analogy which exists between bodily and mental power, not only as respects development and decay, but with regard to the physical processes involved in their exercise.

It is now a well-established physiological fact that mental action is a distinctly physical process, depending primarily on a chemical reaction between the blood and the brain, precisely as muscular action depends primarily on a chemical reaction between the blood and the muscular tissues. Without the free circulation of blood in the brain there can be neither thought nor sensation, neither emotions nor ideas. It necessarily follows that thought, the only form of brain action which we have here to consider, is a process not merely depending upon, but in its turn affecting, the physical condition of the brain, precisely as muscular exertion of any given kind depends on the quality of the muscles employed and affects the condition of those muscles, not at the moment only, but thereafter, conducing to their growth and development if wisely adjusted to their power, or causing waste and decay if excessive and too long continued. It is important to notice that this is not a mere analogy. The relation between thought and the condition of the brain is a reality. So far as this statement affects our ideas about actually existent mental power, it is of little importance; for it is not more useful to announce that a man with a good brain will possess good mental powers than to say that a muscular man will be capable of considerable exertion. But as it is of extreme importance to know of the relation which exists between muscular exercise and the growth or development of bodily strength, so it is highly important for us to remember that the development of mental power depends largely on the exercise of the mind. There is a "training" for the brain as well as for the body—a real physical training—depending, like bodily training, on rulesas to nourishment, method of action, quantity of exercise, and so forth.

When we thus view the matter, we at once recognise the significance of relations formerly regarded as mere analogies between mental and bodily power. Instead of saying that as the body fails of its fair growth and development if overtaxed in early youth, *so* the mind suffers by the attempt to force it into precocious activity, we should now say that the mind suffers in this case in the same actual manner—that is, by the physical deterioration of the material in and through which it acts. Again, the old adage, "mens sana in corpore sano," only needs to be changed into "cerebrum sanum in corpore sano," to express an actual physical reality. The processes by which the brain and the body are nourished, as well as those which produce gradual exhaustion when either is employed for a long time or on arduous work, not only correspond with each other, but are in fact identical in their nature; so that Jeremy Taylor anticipated a comparatively recent scientific discovery when he associated mental and bodily action in the well-known apophthegm, "Every meal is a rescue from one death and lays up for another; and while we think a thought we die." This is true, as Wendell Holmes well remarks, "of the brain as of other organs: the brain can only live by dying. We must all be born again, atom by atom, from hour to hour, or perish all at once beyond repair."

And here it is desirable to explain distinctly that the relations between mind and matter which we are considering are not necessarily connected with any views respecting the questions which have been at issue between materialism and its opponents. We are dealing here with the instrument of thought, not with *that*, whatever it may be, which sets the instrument in motion and regulates its operation. So far indeed as there is any connection between physical researches into the nature of the brain or its employment in thought, and our ideas respecting the individuality of the thinker, the evidence seems not of a nature to alarm even the most cautious. Thus when Huxley maintains that thought is "the expression of molecular changes in that matter of life which is the source of our other vital phenomena," we are still as far as ever from knowing where resides the moving cause to which these changes are due. We have found that the instrument of thought is moved by certain material connecting links before unrecognised; but to conclude that therefore thought is a purely material process, is no more necessarily just than it would be to conclude that the action of a steam-engine depends solely on the eccentric which causes the alternation of the steam-supply. Again, we need find nothing very venturesome in Professor Haughton's idea, that "our successors may even dare to speculate on the changes that converted a crust of bread, or a bottle of wine, in the brain of Swift, Molière, or Shakspeare, into the conception of the gentle Glumdalclitch, the rascally Sganarelle, or the immortal Falstaff," seeing that it would still remain unexplained how such varying results may arise from the same material processes, or how the selfsame fuel may produce no recognisable mental results. The brain does not show in its constitution why such differences should exist. "The lout who lies stretched on the tavern-bench," says Wendell Holmes, "with just mental activity enough to keep his pipe from going out, is the unconscious tenant of a laboratory where such combinations are being constantly made as never Wöhler or Berthelot could put together: where such fabrics are woven, such colours dyed, such problems of mechanism solved, such a commerce carried on with the elements and forces of the outer universe, that the industries of all the factories and trading establishments in the world are mere indolence, and awkwardness, and unproductiveness, compared to the miraculous activities of which his lazy bulk is the unheeding centre." Yet the conscious thought of the

lout remains as unlike as possible to the conscious thought of the philosopher; nor will crusts of bread or bottles of wine educe aught from the lout's brain that men will think worth remembering in future ages.

Moreover, we must remember that we have to deal with facts, let the interpretation of these facts be what it may. The relations between mental activity and material processes affecting the substance of the brain are matters of observation and experiment. We may estimate the importance of such research with direct reference to the brain as the instrument of thought, without inquiring by what processes that instrument is called into action. "The piano which the master touches," to quote yet again from the philosophic pages of Holmes's "Mechanism in Thought and Morals," "must be as thoroughly understood as the musical box or clock which goes of itself by a spring or weight. A slight congestion or softening of the brain shows the least materialistic of philosophers that he must recognise the strict dependence of mind upon its organ in the only condition of life with which we are experimentally acquainted; and what all recognise as soon as disease forces it upon their attention, all thinkers should recognise without waiting for such an irresistible demonstration. They should see that the study of the organ of thought, microscopically, chemically, experimentally, in the lower animals, in individuals and race, in health and in disease, in every aspect of external observation, as well as by internal consciousness, is just as necessary as if the mind were known to be nothing more than a function of the brain, in the same way as digestion of the stomach."

In considering here, however, the growth of the mind, it appears to me sufficient to call attention to the physical aspect of the subject, without entering into an account of what is known about the physical structure of the brain and the manner in which that structure is modified with advancing years. Moreover, I do not think it desirable, in the limited space available for such an essay as the present, to discuss the various forms of mental power; indeed, this is by no means essential where a general view of mental growth and decay is alone in question. Precisely as we can consider the development and decay of the bodily power without entering into a discussion of the various forms in which that power may be manifested, so we can discuss the growth of the mind without considering special forms of mental action.

Nevertheless, we cannot altogether avoid such considerations, simply because we must adopt some rule for determining how to know when mental power is growing. Here, indeed, at the outset, a serious difficulty is encountered. Certain signs of mental decay are sufficiently obvious, but the signs which mark the progress of the mind to its maximum degree of power, as well as the earlier signs of gradually diminishing mental power, are far more difficult of recognition. This is manifest when we consider that they should be more obvious, one would suppose, to the person whose mind is in question than to any other; whereas it is a known fact that men do not readily perceive (certainly are not ready to admit) any falling off in mental power, even when it has become very marked to others. "I, the Professor," says Wendell Holmes in the "Professor at the Breakfast-table," "am very much like other men. I shall not find out when I have used up my affinities. What a blessed thing it is that Nature, when she invented, manufactured, and patented her authors, contrived to make critics out of the chips that were left! Painful as the task is, they never fail to warn the author, in the most impressive manner, of the probabilities of failure in what he has undertaken. Sad as the necessity is to their delicate sensibilities, they never hesitate to advertise him of the decline of his powers, and to press upon him the propriety of retiring before he sinks into imbecility." Notwithstanding the irony, which is just enough so far as it relates to ordinary criticism, there can be no question that when an author's powers are failing, his readers, and especially those who have been his most faithful followers, so to speak, devouring each of his works as it issues from his pen, begin to recognise the decrease of his powers before he is himself conscious that he is losing strength. The case of Scott may be cited as a sufficient illustration, its importance in this respect being derived from the fact that he had long been warmly admired and enthusiastically appreciated by those who at once recognised signs of deterioration in "Count Robert of Paris" and "Castle Dangerous."

Yet judgment is most difficult in such matters. We can readily see why no man should be skilled to detect the signs of change in his own mind, since the self-watching of the growth and decay of mind is an experiment which can be conducted but once, and which is completed only when the mind no longer has the power of grasping all the observed facts and forming a sound opinion upon them. But it is even more natural that those who follow the career of some great mind should often be misled in their judgment as to its varying power. For it must be remembered that the conditions under which such minds are exercised nearly always vary greatly as time proceeds. This circumstance affects chiefly the correctness of ideas formed as to the decay of mental powers, but it has its bearing also on the supposed increase of these powers. For instance, the earlier works of a young author, diffident perhaps of his strength or not quite conscious where his chief strength resides, will often be characterised by a weakness which is in no true sense indicative of want of mental power. A work by the same author when he has made for himself a name, when he knows something of the feeling of the public as to his powers, and when also he has learned to distinguish the qualities he possesses—to see where he is strong and where weak—will have an air of strength and firmness not due, or only partially due, to any real growth of his mental powers. But as I have said, and as experience has repeatedly shown, it is in opinions formed as to the diminution of mental power that the world is most apt to be deceived. How commonly the remark is heard that So-and-so has written himself out, or Such-a-one is not the man he was, when in reality, as those know who are intimate with the author so summarily dismissed, the deterioration justly enough noted is due to circumstances in no way connected with mental capacity. The author who has succeeded in establishing a reputation may not have (nay, very commonly has not) the same reason for exerting his powers to the full, as he had when he was making his reputation. He may have less leisure, more company, new sources of distraction, and so on. The earlier work, his *chef-d'œuvre*, let us say, may have been produced at one great effort, no other subject being allowed to occupy his attention until the masterpiece had been completed—the later and inferior work, hastily accepted as evidence that the author's mind no longer preserves its wonted powers, may have been written hurriedly and piecemeal, and subjected to no jealous revision before passing through the press.

(*To be continued.*)

Sand Grouse in Yorkshire.—Four sand grouse were seen as lately as the middle of June in a cornfield on the edge of Manshead Moor, about four miles south-east of Todmorden, and all of them—two males and two females—were wantonly shot. The place where they were killed is about 900 feet above the sea-level. We may mention that the gradual elevation above the sea that has been recorded for sand grouse in this country is 1,200 feet.—*The Zoologist.*

XUM

A History of the Study of Mathematics at Cambridge. By W. W. Rouse Ball, Fellow and Lecturer of Trinity College, Cambridge. University Press. 1889.)—This is a most interesting little book, containing in its 260 small 8vo. pages an immense amount of information with respect to life at the university in the Middle Ages, and other matters which only bear incidentally on the study of mathematics. The book is only too much compressed, one would continually like to be asking its author for further information which he must possess in order to be able to give the many general summaries of facts for which the book is remarkable. Here is an example: "The hour of dining gradually grew later. In 1570 it was at 9.0, or at Trinity at 10.0. By 1755 it had got shifted to noon. In 1800 it was at 2.15 at Trinity, and at 1.30 at most other colleges, and the senior members of the university began to complain that the afternoon attendance at the schools was in consequence much diminished. A few years later dinner was usually served at 3.0, but until 1850 the hour did not, I think, get later than 5.0. Since then the same movement has gone on, and now (1889) dinner at Trinity is at 7.30." Sir Isaac Newton is much too summarily dealt with, and the controversy with Leibnitz is dismissed thus:—"From what I have read of the voluminous literature on the question, I think, on the whole, it points to the fact that Leibnitz obtained the idea of the differential calculus from a manuscript of Newton's which he saw in 1673." A judgment with which Professor de Morgan certainly would not have concurred. One would like to know to what Mr. Ball refers when he says of Newton, "During the early half of his life he was parsimonious, if not stingy, and he was never liberal in money matters." It is true that during the early and brilliantly fruitful part of his life he was poor, but he was certainly not mean either to his cousin or to his mother. Sir David Brewster gives many stories (some perhaps doubtful) of his freehandedness in money matters in after life. The book is one for reference, and fortunately Mr. Ball has provided his readers with an excellent index.

A USEFUL CEMENT.

The following mixture has been used with the greatest possible success for the cementing of iron railing tops, iron gratings to stoves, &c.: in fact, with such effect as to resist the blows of a sledge-hammer. This mixture is composed of equal parts of sulphur and white lead, with about one-sixth proportion of borax, the three being thoroughly incorporated together so as to form one homogeneous mass. When the application is to be made of this composition, it is wet with strong sulphuric acid, and a thin layer of it is placed between the two pieces of iron, these being at once pressed together. In five days it will be perfectly dry, all traces of the cement having vanished, and the work having every appearance of welding.—*The American Artisan.*

Letters.

The Editor does not hold himself responsible for the opinions or statements of correspondents.]

PHOTOGRAPHS OF LIGHTNING.

To the Editor of Knowledge.

Dear Sir,—I was much interested by the article in the July number of Knowledge on lightning photographs. I think none of the conjectures hit the nail on the head. When I saw Mr. Shepherd's dark flash in the Photographic Exhibition nearly two years ago, at the first moment I thought of solarisation, but that was immediately negatived by the consideration that on that supposition the edges ought to be light. It then occurred to me—and I mentioned it to one of the photographers as I went out—that a flash had struck very shortly before the camera had been uncapped, and had left a tube of air containing nitrous acid gas in its path, and that a subsequent flash illuminated the cloud behind, and where the dispersed light on its way to the camera had to pass through the tube the actinic rays were absorbed. Till about a month ago I thought that this was the true theory, though six or seven weeks ago I received an experimental photograph from Mr. Wimshurst that was puzzling on this view, and I suggested some experiments further to test the view. But after the delivery of the Rede lecture on June 12 my friend the Rev. G. B. Atkinson showed me a photograph obtained by him in the great thunderstorm of June 6, which showed me that the absorption theory could not be maintained. The action must be direct; and I thought the result would be accounted for by the known undoing action of the less refrangible rays. An explanation pointing in the same direction has been brought before the Physical Society by Mr. Clayden, who has since obtained some remarkable experimental results. The experiments are in progress.—Yours very truly, G. G. Stokes.

Lensfield Cottage, Cambridge: July 10, 1889.

DARK LIGHTNING FLASHES.

To the Editor of Knowledge.

Sir,—I notice that you have recently devoted very considerable space to the discussion of the various phenomena exhibited in photographs of lightning. Among these the most obscure is probably the existence of dark images, the so-called dark flashes, and a variety of different theories have been brought forward in the attempt to explain them. It so happened that I was fortunate enough to secure an example of such images among some photographs which I took during the storm on June 6. From certain observations in connection with this plate I was led on to some experiments which I think sufficiently prove that dark flashes are merely a photographic effect produced by the subsequent, or possibly simultaneous, illumination of the clouds.

I have already described some of these experiments in a short note read before the Physical Society, but as that account may not meet the eye of some of your readers, perhaps it may be of interest to describe them again. My dark-flash plate shows four of the dark images and one bright one, as well as another faint but normal image. I felt certain that a particularly fine flash had impressed itself nearly vertically down the middle of the plate, which was exposed altogether to six flashes, and to the diffused light from several others which were either hidden in the clouds or else were out of the field of view.

When I came to develope the plate I at once found that it was greatly over-exposed, and had to treat it very carefully. I was much surprised to find only one triple flash in the corner. The fine vertical flash seemed to be absent; but on inspecting the plate after fixing, I discovered that its image was reversed. Yet the reversal was not complete. Three flashes printed quite dark, so did the branches and upper portion of the vertical one; but the lower part of its main stem (if such a phrase is allowable) showed an unreversed core. Now it was evident that the reversal was due in some way or other to the fact that the plate had been exposed too long. Other photographs taken on the same evening showed no such effect, and they were exposed much less. Hence I conceived that it ought to be possible to

reproduce the phenomenon in photographs of electric sparks.

The first experiment was to photograph a large number of sparks in a dark room on the same plate, but although the images crossed and recrossed each other in all directions there was no indication of reversal. Each spark gave a clear image standing out boldly on the dark background, and points of crossing were even extra bright.

The second was to allow the images of a series of bright sparks from large Leyden jars to impress themselves across the plate. It was then removed from the camera and exposed to diffused gaslight, so that different portions were acted upon for different lengths of time. On developing it was seen (fig. 1)* that the images of the sparks were bright, with a

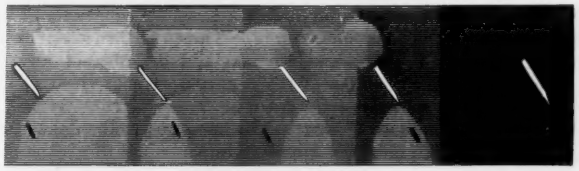


Fig. 1.

dark margin (I speak always of the print obtained), and that this dark margin spread inwards towards the centre as the duration of the exposure to gaslight increased.

Next, I took a series of somewhat less brillant sparks, and exposed half the plate to gaslight for a second. The sparks came out bright on the part not exposed to gaslight, and reversed on the other (fig. 2). It was thus evident that a

Fig. 2.

reversal was easily produced by subsequent general exposure, but the next point was to suggest how that subsequent effect could be produced in nature.

Of course my first experiment did not correctly represent what occurs during a thunderstorm. My sparks were projected upon a dark background. Lightning flashes have masses of white clouds behind them. Hence I photographed a number of sparks, after having previously placed a sheet of white card behind the terminals in order to imitate the cloud. Some of the earlier sparks showed reversal, and and others exhibited marginal reversal with the white core already remarked upon (fig. 3).

Fig. 3.

This experiment seemed almost conclusive, and, after repeating the whole series to confirm the results, I felt assured that I had found the clue to the mystery of dark flashes.

Since then I have pursued the subject further through a long series of experiments which I propose to publish in due time. Meanwhile I may say that I have abundant evidence to show that the reversal of the images is due to subsequent exposure to diffused light, which is apparently powerless to reverse subsequent images. I have therefore had no difficulty whatever in imitating all the observed phenomena, such as the crossing of a dark image by bright ones. From a meteorological point of view this is sufficient. Dark flashes have no existence in nature. They are not even due to any peculiarity of lightning discharges, such as an oscillatory series of flashes. They are a purely photographic effect, the explanation of which belongs to the most obscure portion of the physics of photography. I do not attempt even to suggest a theory at present, but I hope that my experiments, some of which have been kindly suggested to me by Sir G. G. Stokes, will at any rate provide a good deal of material for future elucidation.

In conclusion, allow me to apologise for trespassing so largely on your valuable space.—Yours very truly,

Arthur W. Clayden.

Warleigh, Palace Road, S.W.:
July 19, 1889.

* The woodcuts illustrating this letter have been kindly lent by the Editor of the *Electrician*, in which a short report of Mr. Clayden's paper read before the Physical Society was printed.—Editor.

PHOTOGRAPHS OF THE ORION NEBULA.

To the Editor of Knowledge.

Dear Sir,—I have examined Professor Pickering's lantern slide of the Orion Nebula referred to in his letter in the July number of Knowledge. I infer that this slide represents some of his best work. If so, I cannot trace any nebulosity connecting together the three nebulæ (M 42, M 43, and h 1180) upon it. There is more shown upon my early photograph of November 1886 than can be seen upon this slide, but there is a noticeable light patch to the north following of M 43, which looks like, and has possibly been, assumed by Professor Pickering to be a nebulosity joining the two nebulæ. A comparison with my negatives, however, shows that it is really a photographic defect or stain on the film. That this is the case is proved by the fact that I can only count twenty-two stars on Professor Pickering's photograph within a circle which is described so as to contain the nearest margins of M 43 and h 1180, and includes the area of the connecting nebulosity, while on my photograph I counted within a similar area (taking into account of course the difference of scale) fifty-four stars. I am unable to judge what may be seen on Professor Pickering's original negative; but, on the other hand, he cannot judge of what can be seen on mine from the enlargements published in Knowledge. All negatives lose greatly by copying. I await with interest the publication of Professor Pickering's promised paper.—Yours faithfully,

Isaac Roberts.

Kennessee Maghull, near Liverpool:
July 11, 1889.

To the Editor of Knowledge.

Sir,—Some twenty years ago I noticed a curious phenomenon in the case of a large family with which I was intimately acquainted, namely, that the eldest child resembled closely in appearance, manner, and disposition the maternal parent; the second eldest bore the same close resemblance to the father; the third, again, resembled the mother, and so on through the whole family. It struck me

that this alternate resemblance to male and female parent (the eldest always resembling the mother) might possibly have a wider application than the limits of this particular family, and ever since that time I have taken every opportunity of putting the matter to the test. Though every case did not exhibit the phenomenon so strikingly as the first one observed (in which the great difference in the mental and physical development of the male and female parent was very marked), yet, on the whole, the results of all subsequent observations have tended to confirm my original impression. Perhaps you, or some of your readers who take an interest in such subjects, might think the matter worthy of notice.—Your obedient servant,

FRANCIS HERON
(Demonstrator R. Coll. Surgeons).

Royal College of Surgeons, Dublin:
July 13, 1889.

SOME PROPERTIES OF NUMBERS.

BY ROBERT W. D. CHRISTIE, M.A.

I. (1) BY Pollock's Theorems every odd number may be divided into four squares in four different forms, the algebraic sums of whose roots may equal 1, 3, 5 . . . $2n-1$ up to the maximum, *e.g.*, $73=4^2+4^2+4^2+5^2=2^2+2^2+4^2+7^2=0^2+1^2+6^2+6^2=1^2+2^2+2^2+8^2$. Here the sums of the roots are respectively 17 (the maximum) 15, 13 and 13. By changing the signs of one or more of the roots we may make the sums of the roots equal to any odd number from 1 to 17 inclusive. Thus *e.g.* $73=(-1)^2+2^2+2^2+8^2$ and the sums of the roots $=11=(-1)+2+2+8$, &c.

Lagrange and others have demonstrated that primes of the Form $4N+1$ may be divided into two different integral square numbers, *e.g.*, $5=1^2+2^2$; $13=2^2+3^2$, &c. I have extended this well known theorem as follows:—

$(r^2+1)^m(4N+1)$=two integral squares where m and r may be any integers whatever. Thus, *e.g.*, let $m=2$, $r=2$.

Then $(2^2+1)^2\times29=25\times29=7^2+26^2$.

And since every even square greater than 5 may be divided into four $4N+1$ primes, we can thus resolve any even square into *sixteen* squares by Pollock's, or into *eight* different squares by Lagrange's Theorem, *e.g.*, $18^2=37+41+97+149=41+61+73+149=41+53+73+157=41+73+97+113=41+73+101+109$, &c., &c., and each of these primes may be split up into four or into two different squares *ad libitum*. Thus, *e.g.*, $10^2=13+17+29+41=(2^2+3^2)+(1^2+4^2)+(2^2+5^2)+(4^2+5^2)$ by Lagrange=16 squares by Pollock, since 13, 17, 29, & 41 are odd primes.

(2) By means of the Diophantine Analysis it is easy to show that if $N=a^2+b^3$, it also equals $[\{2mnb+(n^2-m^2)a\}/(m^2+n^2)]^2+[\{2mna+(m^2-n^2)b\}/(m^2+n^2)]^2$, where m and n may be assumed at pleasure. Thus, *e.g.*, if $m=2$, $n=1$, we may say $13=2^2+3^2=(\frac{6}{5})^2+(\frac{1.7}{5})^2$, and so on.

By combining (1) with (2) we can thus split up any prime of Form $4N+1$ into as many pairs of squares as we think proper. Thus, *e.g.*, $6^2=1+5+13+17=1^2+1^2+2^2+2^2+3^2+1^2+4^2$, &c., &c.

If we wish to divide any square number into two other square integers, the following is a convenient equation for our purpose:—$\{2r^2+(2n+1)2r+4n^2+1\}^2=\{2r^2+2r(2n+1)+4n\}^2+\{(2n-1)(2r+2n+1)\}^2$, where n and r may be any integers. Thus, *e.g.*, if $r=3$, $n=2$, we have $65^2=56^2+33^2$. It may be incidentally mentioned that *one* of the three squares is always divisible by 5.

(3) Mainly from the simple fact that $2+2=2\times2$ I have constructed an interesting theorem, which will enable us to turn n integral squares into n other integral squares in $n+1$ different ways. $(na_1^m)^2+(na_2^m)^2+(na_3^m)^2$ . . . $(na_r^m)^2=\{2(a_1^m+a_2^m$ . . . $a_{r-1}^m)-(n-2)a_r^m\}^2+n-1$ corresponding symmetrical expressions, *e.g.*; let $n=3$ $m=1$, then we have $(3a_1)^2+(3a_2)^2+(3a_3)^2=(2a_1+2a_2-a_3)^2+(2a_2+2a_3-a_1)^3+(2a_3+2a_1-a_2)^2=(-2a_1+2a_2-a_3)^2+(2a_2+2a_3+a_1)^2+(2a_3-2a_1-a_2)^2=(2a_1-2a_2-a_3)^2+(-2a_2+2a_3-a_1)^2+(2a_3+2a_1+a_2)^2=(2a_1+2a_2+a_3)^2+(2a_2-2a_3-a_1)^2+(-2a_5+2a_1-a_2)^2$.

If integers be desired, let $a_1=2$ $a_2=5$ $a_3=11$, say, and we have at once $6^2+15^2+33^2=3^2+30^2+21^2=5^2+34^2+13^2=17^2+10^2+31^2=25^2+14^2+23^2$. And since the sum of the roots of the first three (or n) squares always equals the sum of the second three (or n) squares, we can raise or depress the equations *ad libitum*. Thus, *e.g.*, instead of $6^2+15^2+33^2=3^2+30^2+21^2$, we may add or subtract any number from each member of the equation without vitiating it. Thus, *e.g.*, we may write down at once $7^2+16^2+34^2=4^2+31^2+22^2$ or $5^2+14^2+32^2=2^2+29^2+20^2$, and so on.

(4) In order to obtain a square number equal to n other square numbers, we have $U^2=A_1^2+A_2^2$ . . . A_n^2, if $A_1=a_1^2+a_2^2$———a_n^2, and $A_2=2a_1a_n$, $A_3=2a_2a_n$ . . . $A_n=2a_{n-1}a_n$. *E.g.*, suppose we want a square number equal to *seven* other square numbers:—

Let $a_1=1$ $a_2=3$ $a_3=5$ $a_4=7$ $a_5=2$ $a_6=4$ $a_n=8$, say.

Then $A_1=40$ $A_2=16$ $A_3=48$ $A_4=80$ $A_5=112$ $A_6=32$ $A_7=64$. Thus, after cancellation, $21^2=5^2+2^2+6^2+10^2+14^2+4^2+8^2$.

II. A perfect number is one which is equal to the sum of all the lesser numbers which divide it without remainder. These numbers have engaged the attention of mathematicians from very early times. Euclid treats of them in the last proposition of his Ninth Book. No odd perfect number has yet been discovered, and the most eminent mathematicians are at variance on the point. Descartes in 1638 wrote:—"Je juge qu'on peut trouver des nombres impairs véritablement parfaits." On the other hand, Professor Sylvester says, December 15, 1887:—"There seems every reason to believe that Euclid's Perfect Numbers are the only perfect numbers which exist." The formula for a perfect number is $P=2^n(2^{n+1}-1)$ provided $2^{n+1}-1$ be a prime, i.e., provided $n+1$ be a (not *any*) prime. If we could solve the problem "What prime p will make 2^p-1 a prime," there would be little difficulty in obtaining any number of perfect numbers, but as it is, only about a dozen perfect numbers are known.

The first six perfects are 6, 28, 496, 8128, 33550336, 8589869056. Thus, *e.g.*, the factors of 6 are 1, 2, 3, and $1+2+3=6$. Therefore 6 is a perfect number. Again, the factors of 28 are 1, 2, 4, 7, 14, and $1+2+4+7++14=28$. Thus 28 is also a perfect number, and so on with the others. From the above formula for perfects we make the following deductions:—

(1) Every perfect number equals a sequence from unity but from no other number.

(2) Perfects are all of Form $9N+1$ (except the first).

(3) They must end in the digits 6 or 8.

(4) The product of the factors of a Perfect number is an exact power of the Perfect itself, i.e. Product of Factors $=P^n=\{2^n(2^{n+1}-1)\}^n$.

(5) The number of positive integers less than the Perfect and prime to it divided by the Perfect is less than one-half or $\phi(P)/P<\frac{1}{2}$.

(6) Every perfect number except the first equals an *even* number of *odd* cubes, e.g. $28=1^3+3^3$; also $496=1^3+3^3+5^3+7^3$; also Product of Factors of $28=1\times2\times4\times7\times14=784=28^2$ (*v.* No. (4) above).

(7) If P=any perfect number and p any prime number (except 5), then $(P^4 \sim p^4)/5$ is always an integer.

Many other interesting deductions may be drawn.

Secondary Perfects are as difficult to obtain as the primary. The following are all I have been able to obtain easily: $P_2 = 2^5.3.7=672$. $P_2 = 2^9.3.11.31 = 523776$, $P_2 = 2^{13}.3.11.43.127$., $P_2=2^8.5.7.19.37.73$. This means that the sum of the factors of 672 equals twice the number itself, thus e.g. the sum of

1,2,3,4,6,7,8,12,14,16,21,24,28,32,42,48,56,84,96,112,168, 224,336=2×672. Some Perfects the sum of whose factors equals three times the Perfect itself are: $P_3=2^5.3^3.5.7$; $P_3=2^8.3.5.7.19.37.73$; $P_3=2^7.3^6.5.17.23.137.547.1093$.

III. A pretty theorem of Sylvester's is as follows. Every number may be resolved into a sequence in as many ways as it contains odd factors; *e.g.*, 63 has 6 odd factors, viz., 1, 3, 7, 9, 21, 63, and therefore it may be represented by the *six* following sequences and no others:—63=31+32 =20+21+22=8+9+10+11+12+13=6+7+8+9+10 +11+12=3+4+5+6+7+8+9+10+11. On similar principles we are able to deduce that n^m is the sum of n consecutive odd numbers; *e.g.*, $4^3=13+15+17+19$. Or again, n^m equals a sequence of n natural numbers if n be odd and m greater than unity. Thus, *e.g.*,

$$5^2=3+4+5+6+7.$$

IV. We may form squares by means of cubes in various ways. One well-known equation is $\Sigma_n^3 \equiv (\Sigma_n^1)^2$. This means that if we take any number of successive cubes from unity their sum is always a square; *e.g.*, $1^3+2^3+3^3+4^3+5^3 =(1+2+3+4+5)^2=15^2$.

Another equation is $\Sigma^3+(2\Sigma^1)^3=(3\Sigma^2)^2$; *e.g.*, $n=4$ gives us $1^3+2^3+3^3+4^3+\{2(1+2+3+4)\}^3 = \{3(1^2+2^2+3^2+4^2)\}^2=90^2$.

Again, $1^3+3^3+5^3 \text{——} +(2n-1)^3=(n\mathrm{M})^2$ where n is the denominator and M the numerator of any odd convergent of $\sqrt{2}$; *e.g.*, $n=5$ M=7, then $1^3+3^3+5^3+7^3+9^3=(1+3+5 +7+9)(7^2)=35^2$.

While we are dealing with series, the following equations will, I think, be found interesting:—$S_5+S_7=2S_3^2$. Thus $n=3$ gives us $1^5+2^5+3^5+1^7+2^7+3^7=2\{(1^3+2^3+3^3)\}^2$. Other equally pretty equations are:—$7S_6+5S_4=12S_2S_3$ $(3S_5+2S_1^3)_5/5S_4=S_3/S_2$, &c. Thus if we suppose $n=2$, we have

$$7(1^6+2^6)+5(1^4+2^4)=12(1^2+2^2)\times(1^3+2^3)$$
$$i.e.,\ 7\times65+5\times17 \quad =12\times5\times9, \text{ or } 540=540.$$

Again, for the other equation let $n=3$, and we get

$$3(1^5+2^5+3^5)+2(1+2+3^3)\div5(1^4+2^4+3^4)=(1^5+2^3+3^3) \div(1^2+2^2+3^2)$$
$$i.e.,\ 3+276+2\times216 \quad \div5+98 \quad =26\div14$$
$$\text{or} \quad 1260 \quad \div490 \quad =36\div14,$$

which is true, and so on for all values of n.

V. It is impossible to find any two cubes, whose sum or difference is a cube, or even twice a cube, but there are various ways of resolving a cube into three cubes. Euler's well-known formula is somewhat elaborate. One of the simplest is—

$$\{b(b^3+2a^3)\}^3 \equiv \{a(b^3-a^3)\}^3+\{b(b^3-a^3)\}^3+\{a(2b^3+a^3)\}^3,$$

where a and b may be any integers whatever.

To get the sum of three cubes into three other cubes, a simple formula is $(3p^2-q^2)^3+(p^2+q^2+4pq)^3+(p^2+q^2-4pq)^3 \equiv (p^2+q^2)^3+(3p^2+3q^2)^3+(p^2-3q^2)^3$, a formula which may be generalised—Here p and q may be any integers.

Let $p=5$, $q=3$, then $(3\times5^2-3^2)^3+(5^2+3^2+4\times5\times3)^3 +(5^2+3^2-4\times5\times3)^3=(5^2+3^2)^3+3(5^2+3^2)+5^2-3\times3^2)^3$. Thus, after dividing by 2, we get

$$1^3+33^3+47^3=13^3+17^3+51^3,$$

and similarly for all values of p and q.

We can resolve a cube into a number of squares.

Let $x=p^3-3pq^2$, $y=3p^2q-q^3$.

Then

$$x^2+y^2=(p^2+q^2)^3=\{p(p^2+q^2)\}^2+\{q(p^2+q^2)\}^2;$$

and generally

$$(p^2+q^2+r^2 \text{——} +z^2)^3=\{p(p^2+q^2 \text{——} +z^2)\}^2 +\{q(p^2+q^2 \text{——} z^2)\}^2+\{r(p^2+q^2 \text{——} +z^2)\}^2+\&c.$$

Thus, if $p=3$, $q=2$, $r=1$, we get

$$(3^2+2^2+1^2)^3=\{3(3^2+2^2+1^2)\}^2+\{2(3^2+2^2+1^2)\}^2 +\{1(3^2+2^2+1^2)\}2, \text{ or } 14^3=42^2+28^2+14^2.$$

We can resolve a number into three cubes. Let $n=$ the number. Assume $n^3=(n-bx)^3+(cx+1)^3+(dx-1)^3$, and make $b=(c+d)/n^2$.

Then $x=\{3(d^2-c^2-nb^2)/(d^3+c^3-b^3)\}$;

e.g. $n=2$, $b=3$, $c=7$, $d=5$.

Then $x=-\frac{2}{7}$, and $20^3=7^3+14^3+17^3$.

If $b=c$, then $3^3+4^3+5^3=6^3$.

If $b=d$, then $18^3+19^3+21^3=28^3$;

$c=d$, gives us $9^3+10^3=1^3+12^3$, &c. &c.

THE FACE OF THE SKY FOR AUGUST.

BY HERBERT SADLER, F.R.A.S.

SPOTS on the solar surface are becoming rather more frequent, but there have not been many of any considerable size as yet. Conveniently observable minima of Algol occur on the 4th at 10h. 39m. P.M., and on the 27th at 9h. 10m. P.M. The variable star o (Mira) Ceti will arrive at a maximum on the 6th. Mercury comes into superior conjunction with the sun on the 7th, and is practically invisible throughout the month. Venus is a morning star, rising on the 1st at 1h. A.M., with a northern declination of 20° 51′, and an apparent diameter of 18½″. On the last day of the month she rises at 1h. 30m. A.M., her declination having decreased to 19½°, and her diameter to 15″. She passes from Orion through Gemini into Cancer. At about 4h. A.M. on the 18th she will be 26′ due north of the 4th magnitude star ζ Geminorum. Mars is actually a morning star, as he rises on the 1st at 3h. 6m. A.M., and on the 31st at 2h. 58m. A.M., but his diameter does not exceed 4½″ during the month, so that he is practically not worth looking at with a telescope. His path throughout the month is in Cancer. Saturn is invisible, being in conjunction with the sun on the 16th. Jupiter is visible during all the working hours of the night, but owing to his great southern declination is very unfavourably suited for observation. He rises on the 1st at 5h. 20m. P.M. with a southern declination of 23° 22′, and an apparent diameter of 44½″, and on the 31st at 3h. 17m. P.M., with an apparent diameter of 41″. He is nearly stationary throughout the month in Sagittarius, and during the last fortnight will be found about 23′ nearly due north of the 5½ magnitude star 4 Sagittarii. On the evenings of the 1st and 2nd a 9th magnitude star will be seen a little to the north of the planet and its satellites. To his occultation by the moon on the 7th we allude below. The following phenomena of the satellites occur between the times of the planets' being 8° above the horizon, and the sun's being 8° below, on the days named. On the 4th an egress from transit of the third satellite at 10h. 49m. P.M., and the ingress of its shadow at 11h. 31m. On the 6th a transit ingress of the first satellite at 8h. 59m., and ingress of the shadow of the satellite at 9h. 56m., the satellite itself passing off the planet's disc at 11h. 16m. On the 7th a reappearance from eclipse of the first satellite at 9h. 30m. 33s. On the 10th an occultation (disappearance) of the second satellite at 10h. 3m. On the 12th an egress of the shadow of the second satellite at 9h. 52m. On the 13th a transit ingress of the first satellite at 10h. 48m. On the 15th an

egress of the shadow of the first satellite at 8h. 37m., and a reappearance from eclipse of the third at 8h. 37m. 16s. On the evening of the 18th all four satellites will be seen in a line on the following side of the planet. On the 19th an ingress of the shadow of the second satellite at 9h. 46m., and a transit egress of the satellite itself at 10h. 10m. On the 21st at 9h. 57m. an occultation (disappearance) of the first satellite. On the 22nd a transit ingress of the shadow of the first satellite at 8h. 15m., an egress of the satellite itself at 9h. 22m., and an eclipse (disappearance) of the third satellite at 9h. 43m. 52s. On the 26th a transit ingress of the second satellite at 9h. 56m. On the 28th a reappearance from eclipse of the second satellite at 9h. 17m. 47s. On the 29th a disappearance by occultation of the third satellite at 8h. 46m., and a transit ingress of the first at 8h. 57m. On the 30th a reappearance from eclipse of the first satellite at 9h. 44m. 15s. Both Uranus and Neptune are practically invisible during August to the amateur observer. This month is one of the most favourable ones for observing shooting stars in. The most noted shower is that of the Perseids, with a radiant point at the maximum display on August 10 in 11h. 52m. + 56°. Observations of this region of the heavens with an opera-glass will no doubt show stationary meteors, or meteors which shift their position very slowly. Their place and the direction of their shift should be noted for the purpose of determining whether the radiant is a geometrical point, or a circle, or an elliptic area, as suggested with regard to the November meteors.* The radiant point souths at 5h. 37m. A.M. The moon enters her first quarter at 1h. 27m. P.M. on the 4th, is full at 4h. 43m. A.M. on the 11th, enters her last quarter at 10h. 51m. A.M. on the 18th, and is new at 2 o'clock on the afternoon of the 26th. At 10h. 35m. P.M. on August 6 the $6\frac{1}{2}$ magnitude star B.A.C. 5758 will disappear at an angle of 103° from the lunar vertex, and reappear at 11h. 43m. P.M. at an angle of 297° from the vertex. On the 7th, Jupiter and three of his satellites will be occulted by the moon, the first satellite being behind the planet. The occultation of Jupiter takes place at 7h. 4m. P.M., at an angle of 25° from the vertex. The occultation of the planet itself will be preceded by that of the third satellite, and followed by that of the second, and after a little time by that of the fourth. This phenomenon will occur rather more than half an hour before sunset, and the altitude of the moon will be only 13°, so that probably at least four inches aperture will be required to see the satellites. The planet reappears at 8h. 1m., at an angle from the vertex of 290°. At 0h. 18m. A.M. the next morning the 6th magnitude star B.A.C. 6161 will be very near the north point of the lunar limb. On the 12th, at 4h. 7m. A.M., the 6th magnitude star 56 Aquarii will disappear at an angle of 107° from the vertex, and reappear at 4h. 57m., or a quarter of an hour after sunrise, at an angle of 5°. On the 13th, the 5th magnitude star 33 Piscium will disappear at 9h. 13m. P.M. at an angle of 118°, and reappear at 9h. 55m. at an angle of 212°. The 6th magnitude star B.A.C. 17 is occulted at 11h. 46m. P.M. on the 13th, at an angle of 107°, and reappears at 0h. 54m. A.M. the next morning, at an angle of 264°. On the 17th, at 4h. 35m. A.M., there is a near approach of B.A.C. 830, at an angle of 205°. At 1h. 37m. A.M. on the 20th, the $5\frac{1}{2}$ magnitude star B.A.C. 1563 disappears at an angle of 42°, and reappears at 2h. 35m. at an angle of 270°; and there is a near approach of h 106 Tauri at 3h. 33m. A.M. at an angle of 159°. At 2h. 59m. on the morning of the 24th, the 6th magnitude star η Cancri disappears at an angle of 107°, and reappears at an angle of 173° at 3h. 30m.

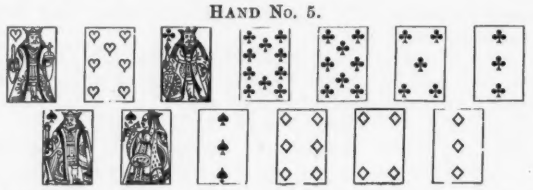
* "Monthly Notices" of the R.A.S., vol. xlvii. p. 69-73.

Whist Column.

BY W. MONTAGU GATTIE.

THE following hand, which is taken from "Whist Developments," by Cavendish, affords an interesting illustration of the principles of the American system of leads.

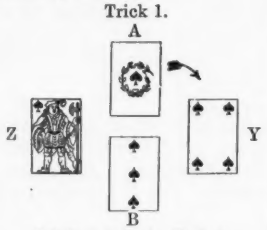
HAND No. 5.



Score:—A B, 1; Y Z, 0.
Z turns up the 2 of hearts.

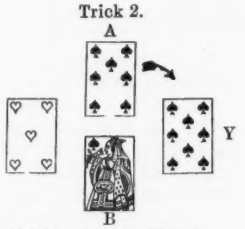
NOTE.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

Trick 1.



Tricks—A B, 1; Y Z, 0.

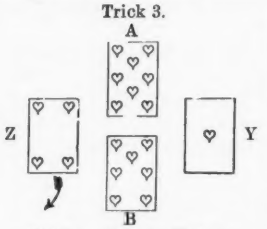
Trick 2.



Tricks—A B, 1; Y Z, 1.

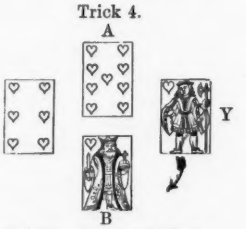
NOTE.—*Trick* 2.—A, on quitting the head of his suit, leads his original fourth-best (see KNOWLEDGE, p. 155). B infers that he has two better than the 7 (*i.e.*, 10 and 9), and the fall of the cards shows that he has all the others.

Trick 3.



Tricks—A B, 1; Y Z, 2.

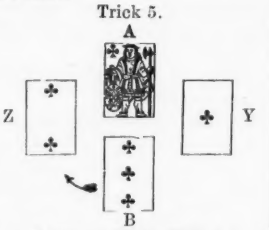
Trick 4.



Tricks—A B, 2; Y Z, 2.

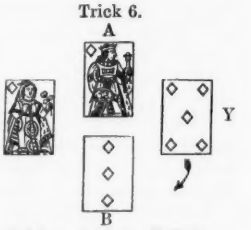
NOTES.—*Trick* 3.—Z has trumped with the 5, and now leads the 4, and he turned up the deuce. As will be seen when we come to discuss the management of trumps in connection with American leads, the rule is to trump with the fourth-best, and to lead the fourth-best of those remaining. Therefore Z has three trumps higher than the 5, and held at least six of them originally. *Trick* 4.—The 3 of hearts is marked in Y's hand; the remaining hearts are in Z's hand.

Trick 5.



Tricks—A B, 2; Y Z, 3.

Trick 6.

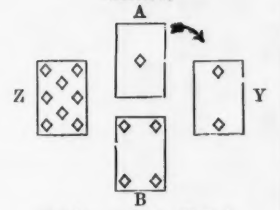


Tricks—A B, 3; Y Z, 3.

NOTE.—*Trick* 5.—B does not lead the king of spades, because he knows one adversary will trump and the other will discard (see notes to Tricks 2 and 4). His object is to secure the required four tricks in clubs and diamonds (see score), and to prevent the adverse trumps from making separately. Nothing is to be gained by leading the

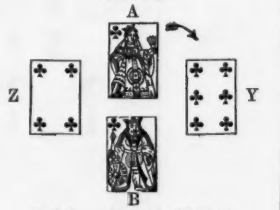
fourth-best club, and exposing the hand with all the trumps against, and B therefore leads the smallest.

Trick 7.



Tricks--A B, 4; Y Z, 3.

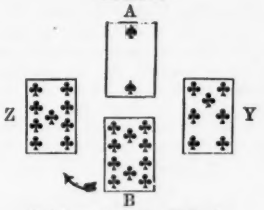
Trick 8.



Tricks—A B, 5; Y Z, 3.

NOTE.—B wins A's queen of clubs, the only chance being that Y and Z may each hold another club. If A remains with the lead, he must continue with a spade; Y of course trumps, and Z discards his losing club, and wins all the remaining tricks.

Trick 9.



Tricks—A B, 6; Y Z, 3.

YZ win the remaining tricks, and score the odd trick and two by honours, and

AB SAVE THE GAME.

A's Hand.	B's Hand.	Y's Hand.	Z's Hand.
H.—9, 8.	H.—Kg, 7.	H.—Ace, Kn, 3.	H.—Qn, 10, 6, 5,
S.—Ace, 10, 9, 7,	S.—Kg, Q, 3.	S.—8, 4.	4, 2.
6, 5, 2.	D.—6, 4, 3.	D.—Kn, 9, 7, 5,	S.—Kn.
D.—Ace, Kg.	C.—Kg, 10, 8, 5,	2.	D.—Qn, 10, 8.
C.—Qn, Kn.	3.	C.—Ace, 7, 6.	C.—9, 4, 2.

Remarks.—At Trick 7 A leads the ace of diamonds, as, if he keeps a card with which he can get the lead when he has only spades left, he must lose the game.

If, at Trick 2, A leads the deuce of spades, as was the practice before the introduction of American leads, AB lose the game, for the reason that B cannot place the spade suit. In that case, at Trick 5, B will lead the king of spades to force the strong trump hand. In this he will succeed; but he will also enable Y to discard a club. Z, following this indication of Y's suit, will lead the queen of diamonds; A winning with the king of diamonds will continue with the queen of clubs, to which Y will play the ace; and whether Y leads diamonds or clubs, A B will not be able to make more than five tricks, and will therefore lose the game.

On the other hand, it may be pointed out that Z affords B valuable information as to the position of the trumps by his play at Tricks 2, 3, and 4. It so often happens that such information is useful in playing a defensive game that some good players are opposed on this account to the extension of the American code to the trump suit.

ELEMENTARY EXPLANATION OF THE PLAY.

Trick 1.—A opens his longest suit and leads the ace, which is the correct play when holding four or more others. Y, B, and Z play their smallest spades.

Trick 2.—A rightly continues his suit so as to clear it if possible. He is not deterred by the fall of the knave, for Z may have both king and queen, and in any case A is too weak to lead trumps. As things turn out, he forces a trump from the strong trump hand, although Z is so rich in them that it makes no difference to him. Note that the king of spades after this trick is marked in B's hand.

Trick 3.—Having still five trumps to the queen left, Z leads a small one; excepting the queen of diamonds he has no plain cards of his own to protect, but he plays to save any good cards his partner may hold from falling to a hostile "ruff." Y of course plays the ace, so as to ensure a second round.

Trick 4.—Y follows the almost invariable rule to return a partner's trump lead at the first opportunity, and, as he has only two of the suit remaining, he rightly leads the higher of them. With knave and two others left, he would return the lowest. Z plays the 6 to show that he has it, for his partner knows that he has the deuce as it was the turn-up card.

Trick 5.—B having reason to think that by continuing his partner's suit he will enable one adversary to trump and the other to discard, determines to open his own long suit. A, as third player, having two cards in sequence, plays the lower one; B now knows that the queen is with A or Z, since Y has to win knave with ace; but if A had played the queen, there would have been no evidence at all as to the whereabouts of the knave.

Trick 6.—Y opens his longest suit.

Trick 7.—Ordinarily A should retain as long as possible the command of his adversary's suit; but, as has already been explained, there is a special reason for his disposing of any card that would put the lead into his hand later on. Therefore he leads out his ace of diamonds.

Trick 8.—The queen and knave of clubs being played, the king and 10 are of equal value. B knows that his partner has no more clubs (for he has all the remaining spades), and he wins the queen, as the only chance of making another trick in the suit, and so saving the game.

Chess Column.

BY I. GUNSBERG (MEPHISTO).

[Contributions of general interest to chess players are invited. Mr. Gunsberg will be pleased to give his opinion on any matter submitted for his decision.]

PROBLEM BY HERR EICHSTADT.

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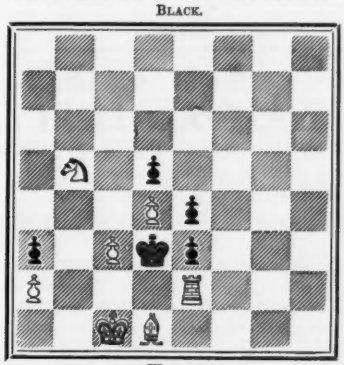

WHITE.

White to play and mate in three moves.
White, seven pieces; Black, five pieces.

Game played May 2, in the New York Tournament.

IRREGULAR OPENING.

WHITE. J. M. Hanham.	BLACK. I. Gunsberg.	WHITE. J. M. Hanham.	BLACK. I. Gunsberg.
1. P to Q4	P to Q4	24. B to Kt4	B to Q2
2. P to KB4 (*a*)	P to KKt3 (*b*)	25. B to R4	Kt to B4 (*n*)
3. P to K3	B to Kt2	26. B to B2	P to KR4 (*o*)
4. B to Q3	P to Kt3	27. B to K2	Kt to Q3 (*p*)
5. P to B3 (*c*)	B to Kt2	28. BP × P	P × P
6. Kt to B3	Kt to Q2 (*d*)	29. P × P	B × P
7. QKt to Q2	KKt to B3	30. Kt to B4	Q to B2 (*q*)
8. Castles	Castles (*e*)	31. B to B3	B to K3
9. Kt to Kt5	P to K3	32. Kt × B	Q × Kt
10. R to B2	Kt to Ksq	33. Q to Q3	K to Kt2
11. Kt to Bsq	Kt to Q3 (*f*)	34. Kt to Q2	Kt(Q3) to B5 (*r*)
12. Kt to Kt3	P to QB4 !	35. Kt to Ktsq (*s*)	B to B3
13. B to Q2 (*g*)	Q to K2 (*h*)	36. P to K4	P × P
14. B to Ksq	QR to Bsq	37. B × P	R to Q2
15. R to QBsq	R to B2	38. Q to B3	Kt to K4
16. KR to B2	KR to Bsq	39. Q to K2	Kt to Kt5
17. Kt to Bsq (*i*)	P to B3	40. B to B5	Kt to R5 (*t*)
18. Kt to R3	P to K4 (*j*)	41. Q × P	Kt × B
19. B to B2	P to B5 (*k*)	42. P × Kt	R(Bsq) to Qsq (*u*)
20. B to K2	B to B3 (*l*)	43. B to B3 (*v*)	Q to K6 (ch) (*w*)
21. P to QKt3	P × P	44. K to Rsq	R to Q8 (ch)
22. P × P	P to QKt4 (*m*)	45. Q to Bsq	Q to B5
23. P to QKt4	Kt to Kt3	Resigns	

NOTES.

(*a*) This move constitutes the Stone-wall Opening. As its name implies, the object is to erect a strong barrier against Black's advance, and to secure a draw thereby.

(*b*) I find that the cross-action of the two Bishops posted on KKt2 and QKt2 may be utilised with great effect in close games. Black must, however, always be alive to the danger of a possible advance by White on the King's or Queen's Bishops' files; he must also keep his Pawns well in hand until the proper moment arrives for an advance on the flank of the lines commanded by the Bishops.

(*c*) It is an advantage for Black that White is induced to make such an inactive move, blocking one square of the QKt, and forego any intention of an immediate advance on the Queen's side.

(*d*) White having rendered his Queen's side inactive, it is Black's intention (after having provided for his own safety) to advance, *viâ* P to QB4, with the hope of placing a Pawn on B5, or, otherwise, weakening the White Queen's side. This is the plan of battle on which the whole game is decided, as will be seen.

(*e*) Black now has less to fear from an advance on the King's side; still he should have played P to K3 earlier.

(*f*) This Knight is very well posted both for attack or defence, and the QKt is made available to play to B3 if necessary; a break-up of the position by means of P to K4 by White is also prevented, and Black has greater freedom of action.

(*g*) To take the Pawn would not be good as Black would obtain the open Kt's file, and the possibility of attack by Q to Kt3 in conjunction with the position of the KB on Kt2 would constitute a weakness in White's game. White's intention seems to be to post his QB on KB2 in defence of his Pawn.

(*h*) Makes the KR available for the advance on the Queen's side for which Black is steadily working, and it also liberates the KBP for an advance if necessary.

I. GUNSBERG.
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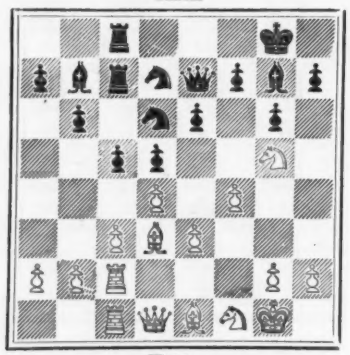

WHITE.
J. M. HANHAM.
Position after White's seventeeth move.

(*i*) It is not quite clear why he retired the Kt; perhaps he had some intention of advancing on the King's side, but found that it was rather *too late*.

(*j*) Every piece of Black supports the advance, and whichever way White takes, Black obtains a strong centre; whereas the White King's Pawn will remain very weak.

(*k*) Black has waited until the position is ripe for this advance. It is difficult to decide whether P to K5 would not have blocked the game too much. Now, although P to B5 also seems to block the game, yet a player is never at a loss to continue the pressure in a similar position, against the Queen's side.

(*l*) A very effective demonstration, which compels White himself to open up the Queen's side. Black threatens B to R5. Against this R to Q2 is no good on account of Kt to K5, he has therefore nothing left, but to move his QKtP which opens up the file for the two Rooks, as if they had been played there for the purpose, by pre-arrangement.

(*m*) To prevent White getting rid of his weakness by playing P to B4.

(*n*) Gaining time as White cannot take the Kt without losing the QBP.

(*o*) Compelling the other B to retire for the same reason.

(*p*) P to K5 would have made the game much harder, but Black's advantage on the Queen's side ought to have told in his favour. White now seizes a favourable opportunity to relieve the pressure and simplify matters by exchanging.

I. GUNSBERG.
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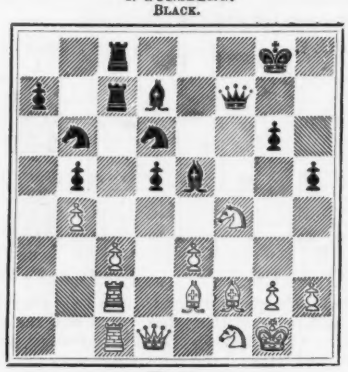


WHITE.
J. M. HANHAM.
Position after Black's thirtieth move.

(*q*) White has succeeded in obtaining a counter attack. If Black plays B × Kt the White B finds a strong square on Q5.

(*r*) Black was bound to prevent the Kt playing to Q4 *viâ* Kt 3. If now Kt to Kt3 Black plays Kt to R6.

(*s*) This gives Black very valuable time.

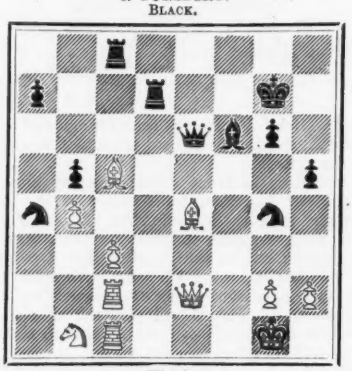
(*t*) The game was adjourned in this very interesting position. It does not seem that White has any good square to play his Bishop on, and the move that follows is the natural outcome of the position.

(*u*) White did not foresee this move when capturing the Pawn.

(*v*) This is fatal at once, but his game was bad anyway, for if, instead of this, 43. Q to K2, Q to K4. 44. P to Kt3, B to Kt4, threatening if R moves B to K6(ch) winning.

(*w*) Black now forces the mate in a few moves.

I. GUNSBERG.
BLACK.



WHITE.
J. M. HANHAM.
Position after Black's fortieth move.

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